« توانا بود هر که دانا بود »

Studies on the Protein Content of cow's milk.

By

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A CONTRIBUTION TO THE STUDY OF THE VARIATIONS OF PROTEIN CONTENT OF COW'S MILK DURING LACTATION.

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Contents.

Introduction.

The object of this investigation was to study the genetical aspect of the protein, and particularly the casein, content of the milk of dairy cattle. Unless the whole lactation period be studied, it is not possible to obtain an accurate figure for the lactation yield. Since genetical research demands the analysis of the yields of a large number of animals, and since the method of analysing the content of the milk in respect of protein and casein is complicated and time consuming, it was obvious, at the outset, that detailed information was required on the variation of the content of the milk in these respects according to the stage of lactation. In other words, an answer was required to the question "How frequently during the lactation period is it necessary to measure the protein and casein content of the milk of a cow in order to obtain a reasonably accurate figure for the lactation yield of that cow ?". To answer this question detailed information was required/

quired concerning the week to week variation in the lactation period. Two possible methods of doing this appeared to be:-

(1) To analyse regularly at short intervals the milk of several cows from the beginning until the end of their lactations and from the figures obtained deduce the general trend and the extent of these variations for the whole lactation time.

(2) To take a greater number of cows at different stages of lactation and analyse their milk at short intervals during a few months only. Several cows being under examination at the same time for any stage of lactation, the analysis of the figures obtained would enable us to explore step by step the whole lactation curve with regard to the variations in question.

The second method curtailed the time required for the whole experiment and was adopted.

ANIMALS.

Twenty-seven cows were selected from the experimental farms of the Institute, where the animals are kept under standard conditions. The system of rationing is kept constant and the quantity of the feeding depends only upon the yields of the cows. Differences in the composition of the milk may therefore be attributed to age, stage of lactation, and/

and the individuality of the cow.

The particulars of these cows which may be of interest here are set out in Table 1.

Table 1 resuming the material of work.

Cow No.	Breed	Age in mths.	Period of lactation in which the cow was under examination.
1	Beef/Dairy Shorthorn	60	1st-11th week
2	Beef Shorthorn	64	1st-12th "
3	Ayrshire	87	1st-11th "
4	Ayrshire	79	1st-14th "
5	Shorthorn/Ayrshire	53	3rd-13th "
6	Beef Shorthorn	37	3rd-19th "
7	Jersey	44	5th-21st "
8	Jersey	50	5th-21st "
9	Beef/Dairy Shorthorn	60	6th-22nd "
10	Shorthorn/Ayrshire	59	8th-18th "
11	Ayrshire	67	11th-27th "
12	Dairy/Shorthorn	68	15th-31st "
13	Dairy/Beef Shorthorn	48	15th-31st "
14	Ayrshire	43	20th-36th "
15	Dairy/Beef Shorthorn	52	20th-36th "
16	Ayrshire	36	21st-39th " (dried off)
17	Ayrshire	41	21st-37th "
18	Ayrshire	74	22nd-38th "
19	Ayrshire	44	22nd-38th "
20	Ayrshire	42	23rd-39th "

Table 1 (contd.)

Cow No.	Breed	Age in mths.	Period of lactation in which the cow was under examination.
21	Ayrshire	40	24th-40th week
22	Ayrshire	75	25th-41st "
23	Jersey	63	31st-42nd " (dried off)
24	Beef Shorthorn	88	40th-41st "
25	Ayrshire	100	40th-52nd "
26	Ayrshire	74	40th-51st " (dried off)
27	Ayrshire	75	44th-46th " (dried off)

Within the periods given in this table the milk of each cow was regularly analysed at intervals of seven days. Occasionally, due to unavoidable circumstances, this interval was eight or nine days. The work was carried on for the majority of the cows during eighteen weeks. This period was shorter for some of them either because they dried off before the end of the work, or they had not yet calved when it was started, etc.

METHODS.

SAMPLING. All the usual precautions were taken in the collection of the samples, i.e.:-

(1) The bottles were clean and dry,

(2) The whole yield (including the strippings) was well mixed just before sampling.

(3)/

Before Sampling make certain—

1. The Bottles are CLEAN and DRY.
2. The whole yield (including the Strippings) is WELL MIXED just before Sampling.

Name of Cow..............................

Date ....

Morning yield in Lbs..................

Evening yield in Lbs..................

(3) Each bottle was carefully labelled.

To facilitate this work and avoid errors, special labels with these directions were printed for the sample bottles, the words clean, dry and well mixed being printed in large capital letters.

The cows on the experimental farms are usually milked twice daily at an interval of twelve hours. Variation in the interval rarely amounts to more than 15 minutes. A few of the high yielding cows are, for a portion of their lactation, milked three times a day at eight-hour intervals. The amount of milk collected from each cow was weighed to the nearest quarter of a pound and samples taken from each milking of each cow were placed in a refrigerator, and sent on the following morning to the Institute. In the laboratory representative samples for twenty-four hours of each cow were then obtained by mixing appropriate quantities of milk from each bottle.

CHEMICAL ANALYSIS. The total protein nitrogen was determined by precipitation by trichloracetic acid and a Kjeldahl digestion, as described by Sanders (1).

In order to test the reliability of the methods of determining casein, results obtained by the volumetric (Van Slyke) (2), colorimetric (Leroy) (3) and official methods were compared. The first two, though invaluable for practical purposes and cheese-making/

making on account of their rapidity, did not seem to be accurate enough for this investigation. The official method was therefore adopted with the improvement recently introduced by Moir (4), where the casein is precipitated at its iso-electric point by the use of a buffer solution of acetic acid and sodium acetate.

From the well-mixed sample prepared as above, ten ml. were pipetted into a tared weighing bottle and weighed to the nearest centigram. Two other ten ml. portions were pipetted into covered beakers. The weight of the milk in the weighing bottle was taken to be the same as that of the milk pipetted into the beakers. This is generally true, but slight differences may be observed when the sample is very creamy and particles of the cream stick against the side of the pipette. This point has been taken into consideration when determining the standard error.

DETERMINATION OF TOTAL PROTEIN NITROGEN. Ten ml. of a 2.43N (approximately 10%) trichloracetic acid solution were added to one of the beakers mentioned above; the protein was completely precipitated at once, and filtered through a 12.5 cm. No. 12 Whatman filter paper. The Biuret test was tried in the filtrate and negative results were always obtained. In order to remove the part of the precipitate/

precipitate adhering to the side of the beaker about twenty ml. of distilled water were added to the beaker and 5 or 6 ml. of nitrogen-free concentrated sulphuric acid were poured down the side of the beaker; the remainder of the precipitate dissolved by the heat produced in this mixture was poured into a Kjeldahl flask. This was repeated several times and completed each time by scraping a glass rod against the side of the beaker until the removal was complete. Finally the filter paper and the precipitate were added to the Kjeldahl flask. The digestion, distilation, and titration were carried out in the usual way, selenium (about .08 of a gram) being used as catalyst during the digestion.

DETERMINATION OF CASEIN NITROGEN. The milk placed in the other beaker mentioned above was diluted with about 50 ml. of distilled water at 40-42° centigrade. One and a half ml. of a 1.67 N acetic acid solution were added immediately after the water, and the mixture was gently stirred. The beaker was then left to stand for about 5-10 minutes after which 4.5 ml. of a 0.25 N sodium acetate solution were added, and the mixture was allowed to stand for 30-40 minutes before being filtered. Moir recommends an interval of 20 minutes between the additions of acetic acid and sodium acetate, and a further interval of one hour before filtration. These intervals, as McDowal/

McDowal and McDowelle have pointed out "seem unnecessarily long, as neither the final PH nor the casein result is affected by adopting much shorter intervals e.g. 5 and 15 minutes respectively." (5) After the precipitate had settled, it was washed three times by decantation and transferred to the filter-paper by two further washings. The rest of the experiment was carried out as for the total protein.

DETERMINATION OF ALBUMIN+GLOBULIN NITROGEN. This was done for each sample by subtracting the casein nitrogen from the total protein nitrogen.

Blank experiments were carried out from time to time and the proper correction applied to the results.

ERRORS. None of these determinations was made in duplicate. The systematic errors were reduced to a minimum by always using the same pipette, starting each measurement with burettes at the same graduation mark, using the same quantities of indicator, and so on. But even so, no reliable information could be drawn from the figures obtained, if we had not an exact idea of the magnitude of these errors. This was determined by analyses carried out on a sample of milk, from cow No. 8, a Jersey cow whose milk was generally very creamy and/

and left particles on the side of the pipette. ten determinations of the total protein nitrogen, and ten determinations of the casein nitrogen were carried out on this sample; the albumin+globulin nitrogen was calculated each time by difference. The mean and the standard error of the results obtained are set out below for each case:-

	Mean of ten determinations made on the same sample.	Standard error.
Total protein nitrogen	0.5921	± 0.0043
Casein nitrogen	0.4788	± 0.0047
Albumin+globulin nitrogen	0.1133	± 0.0066

Thus the standard error for casein nitrogen is higher than for total protein nitrogen. In the case of A.+ G.N. the standard error was also determined theoretically by using the formulae

$$\sigma A + G = \sqrt{\sigma p^2 + \sigma c^2}$$

and the result ± 0.0064 was close to the figure given above.

For a less creamy sample which would leave the pipette clearer these errors would probably be smaller.

ANALYSIS AND INTERPRETATION OF THE DATA.

The statistical analysis of the figures was made by "methode des couples" (6) or the method of "pairing"/

"pairing". This method has been used in many fields of biological investigations, but as far as the writer knows, it has not been used for the study of variations of the kind under examination. Its application to these data was considered not only legitimate, but as being the best means of securing reliable information from such a small number of observations.

All it was hoped to get from these data was the answer to the question: Does the protein-content of milk vary during the lactation period, and if so, how ?

A positive answer to the first part of the question was easily obtained from the examination of the figures of individual cows, as the variations observed in the milk of some of them were sometimes far beyond the limits $\pm 2\delta$ which could be ascribed to the systematic errors of the experiment.

To get the answer to the second part of the question was somewhat more difficult and much more laborious. The differences observed in the composition of the milk of the cows under examination could be ascribed as mentioned above, to the interaction of the breed, age, stage of lactation, heredity, individuality of the cow, and probably to some other unknown causes. By the use of the method/

method known as "factorial arrangement" by modern statisticians, and the analysis of the arrangement obtained, it is possible, though not always easy, to deduce the way in which each single factor interacts with the others, in other words to find what would be the influence of one definite factor if all the others were eliminated. Hence to study the influence of lactation-factor, with which this paper is concerned, we classified our data according to the weeks of lactation as shown in tables 2, 3, and 4; and the method of "pairing" was applied to this arrangement.

Owing to the fact that the length of lactation(s) is different for different cows, and that only data for parts of lactation were available, the "factorial arrangement" was carried out separately for the first thirty and the last sixteen weeks of lactation.

TABLE 2

Milligrams of total protein nitrogen in 100 grams of milk

Weeks in lactation

Cow No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	612	486	427		421	427	459	436	464	471	463																			
2	592	512	437	433	409	405	422	442	482	453	470	457																		
3	672	563	480	465	440	426	435	468	460	523	510																			
4	580	476	453	440	420	430	408	440	464	460	462	451	462																	
5			455	425	442	420	450	404	433	503	451	464	452																	
6			475	445	488	476	471	477	482	480	461	468	482	491	509	528	514	527	505											
7					487	493	484	478	457	460	469	462	469	455	484	505	498	552	550	555	570									
8					549	517	489	531		546	527	572	530	481	511	484	496	519	521	543	539									
9						425	431	432	448	448	447	441	452	467	463	442	452	476		503	509	504								
10								496	452	424	436	448	449	453	509	460	492	494												
11											535	415	417	450	431	452	446	430	445	440	418	449	445	489	467	468	481			
12															470	484	508	526	499	514	532	510	486	508	502	492	537	547	525	535
13															493		477	500	492		513	472	493	482	457	460	513	504	500	536
14																				556	679	585	607	589	608	595	590	582	516	545
15																				503	498	465	492	480	466	500	468	495	496	489
16																					483	540	547	498	504	496	489	480	473	500
17																					516	523	540	537	514	508	524	505	509	469
18																						462	443	571	448	460	459	475	443	438
19																						651	545	558	545	555	555	542	548	543
20																							525	513	517	554	538	534	527	522
21																								487		552	484	518	511	495
22																									573	480	551	608	572	644

Weeks before the end of lactation

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Cow No.
409	405	422	442	482	453	470	457									2
	421	427	459	436	464	471	463									1
436	448	449	453	509	460	492	494									10
532	510	486	508	502	492	537	547	525	535	542						12
441	452	467	463	442	452	476		503	509	504						9
537	514	508	524	505	509	469	500	507	516	509	531		528			17
		526	562	540	483	507	496	506	500	526	551		537	499		24
493		477	500	492		513	472	493	482	457	460	513	504	500	536	13
					457	486	480	467	515	530	541	584	571	573	561	25
				627	628	626	540	644	601	630	647	637	654	652	655	23
													644	614	661	26
														511	634	27

Table 3

Milligrams of casein nitrogen in 100 grams of milk.

Weeks in lactation

Cow No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	452	392	346	319	324	338	367	345	374	362	351																			
2	469	409	354	341	309	318	336	352	388	359	365	341																		
3	569	474	394	384	368	373	365	403	384	431	429																			
4	486	388	386	370	362		337		383	403	404	380	394																	
5			391	357	372	359	373	334	369	400		380	368																	
6			400	394	388	385	398	393	399	404	397	390	403	405	427	440	418	431												
7					391	409	410	386	354	381	318	388	382	347	392	386	407	458	447	456	467									
8					406	416	416	425	427	445	428	435	441	396	471	430	409	420	440	437	446									
9						343	336	340	348	353	346	336	343	345	359	321	341	370		375	387	354								
10								366	364	346	336	356	361	358	414	358	411	406												
11											429	344	353	351	356	377	356	367	355	350	325	353	348	464		372	367			
12															393	404	418	426	413		443	414	405	412	403	390	442	454	430	
13															412	415	359	422	406	413	426	383	409	399	385	394	416	409	409	417
14																				488	473	483	481	488	505	493	477		478	451
15																				393	399	402	400	378	385	392	372	392	392	356
16																					399	395	344	407	413	388	404	402	380	409
17																					419	423	470	442	416	424	439	381	418	380
18																						396	362	382	376	403	394	369	366	360
19																						573	418	434	424	424	426	425	430	415
20																							440	416	432	441	431	438	436	423
21																								418		461	430	446	436	434
22																									501	474	479	528	444	524

Weeks before the end of lactation

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Cow No.
309	318	336	352	388	359	365	341									2
319	324	338	367	345	374	362	351									1
336	356	361	358	414	358	441	406									10
443	414	405	412	403	390	442	454	430								12
336	343	345	359	321	341	370		375	387	354						9
442	416	424	439	381	418	380	394	411	398	387		406	418			17
		404	448	427	405	418	388	398	389	414	423		387	357		24
412	415	359	422	406	413	426	383	409	399	385	394	416	409	409	417	13
					334	381	362	340	378	394	405	402	391	407	403	25
				524	516	524	481	507	501	530	538	519	530	537	548	23
													517	519	542	26
														356	458	27

TABLE 4

Milligrams of albumin and globulin nitrogen in 100 grams of milk

Weeks in lactation

Cow No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
No.1	160	94	81		97	89	92	91	89	108	111																			
2	123	102	83	92	100	87	86	90	94	93	105	117																		
3	102	90	86	81	72	54	70	65	76	91	81																			
4	94	87	68	70	58		71		81	57	58	71	68																	
5			63	68	70	61	76	70	64	103		84	85																	
6			75	51	100	91	73	84	82	76	64	78	80	86	82	88	96	96												
7					97	84	74	92	102	79	150	74	88	108	92	119	91	94	103	99	104									
8					144	101	73	105		101	99	92	89	84	40	55	88	99	81	106	93	102								
9						81	95	92	101	95	101	105	108	122	104	120	110	106		128	122	150								
10								130	87	77	101	91	88	95	94	102	82	88												
11											106	71	63	99	75	75	90	63	90	90	93	96	97	25		96	113			
12															76	81	90	100	86		89	96	82	96	99	102	95	93	95	
13															81		118	78	86		86	90	84	84	72	66	97	96	91	119
14																				68	207	102	126	101	103	102	113		38	94
15																				110	99	62	92	102	81	108	95	103	104	133
16																					84	145	203	90	91	108	85	78	93	91
17																					97	100	70	95	98	84	85	123	92	89
18																						67	81	189	72	56	65	105	77	78
19																						77	127	124	121	131	129	117	118	128
20																							85	97	85	113	107	96	91	100
21																								68		91	54	72	75	61
22																									72	5	72	80	128	120

Weeks before the end of lactation

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Cow No.
100	87	86	90	94	93	105	117									2
	97	89	92	91	89	108	111									1
101	91	88	95	94	102	82	88									10
89	96	82	96	99	102	95	93	95								12
105	108	122	104	120	110	106		128	122	150						9
95	98	84	85	123	92	89	106	96	117	121			110			17
		122	114	114	79	88	108	108	111	112	128		149	141		24
81		118	78	86		86	90	84	84	72	66	97	96	91	119	13
					122	105	118	127	137	136	135	182	181	166	158	25
				103	112	102	60	136	100	100	109	117	124	115	107	23
													126	96	119	26
														155	176	27

In each of the above tables the figures corresponding to any week of lactation (vertical columns) were compared with those of the week immediately preceding as follows:

A "couple" or a "pair of figures" being defined here as two figures obtained from the milk of the same cow in two consecutive weeks, every figure in one column which could not be paired with a figure of the adjoining column was discarded from the comparison. Then each figure of the column $_{N+1}$ was subtracted from the corresponding figure of the column N and the following statistics were determined:

The mean of the differences obtained,

The variance of these differences,

The variance of the mean of these differences,

The standard error of the mean of these differences, and the value:

$$t = \frac{\text{mean}}{\text{standard error of the mean}}$$

which was used to test the significance of the result by the "Student"'s table (7).

The two examples given below illustrate the details of the method.

Example 1. Comparison of the tenth with the eleventh week of lactation regarding the total protein content of milk (See table 2).

Cow No./

Cow No.	10th week	11th week	d	d^2
1	471	463	+ 8	64
2	453	470	-17	289
3	523	510	+13	169
4	460	462	- 2	4
5	503	451	+52	2704
6	480	461	+19	361
7	460	469	- 9	81
8	546	527	+19	361
9	448	447	+ 1	1
10	424	436	-12	144
11	-	535 (discarded)	-	-
Totals	4768	4696	+112 - 40 + 72	4178
Means	476.8	469.6	+7.2	417.8

Variance of the differences = $md^2 - (md)^2 = 417.8 - 51.84 = 365.96$. Variance of the mean of the differences $\frac{365.96}{9} = 40.66$. Standard error of the mean of the differences $= \sqrt{40.66} = 6.376$. $t = \frac{7.2}{6.376} = 1.13$. In consulting the "Student"'s table we will see that for n = 9 (n is the number of degrees of freedom or the number of independent comparisons) and t = 1.13, p (the probability of falling outside ± t) is between .3 and .2 and consequently the difference observed between the means of the two weeks is not significant, since/

since the statisticians do not recognize as significant any difference for which P is greater than .05. Differences of this kind are considered to be due to random sampling.

Example 2. Comparison of the third with the fourth week of lactation regarding the casein content of milk (See table 3).

Cow No.	3rd week	4th week	d	d^2
1	346	319	+27	729
2	354	341	+13	169
3	394	384	+10	100
4	386	370	+16	256
5	391	357	+34	1156
6	400	394	+ 6	36
Totals	2271	2165	+106	2446
Means	378.5	360.8	+ 17.6	407.66

Variance of the differences..................97.9

Variance of the mean of the differences........19.58

Standard error of the mean of the differences.. 4.4

t.. 4

number of degrees of freedom.................. 5

P..............................smaller than .02

and consequently the difference observed between the means of the two weeks is highly significant.

This arithmetical procedure was carried out for each of the above tables, with the following results:

A)/

A) Total Protein nitrogen.

(1) A regular and highly significant decrease in the % of T.P.N. was observed from the beginning until the fourth week of lactation.

(2) From the fourth week towards the end of lactation the mean differences of the two consecutive weeks were sometimes positive, and sometimes negative. Tésted by the "Student"'s table, these were or were not significant, in such a way as one could not draw any legitimate conclusion.

If there were a regular trend after the fourth week but one which was too small to be readily detected with the number of degrees of freedom present and with the comparison of consecutive week-valueś, it might nevertheless be possible to detect it by comparing the figures for every second week or at even longer intervals, for the effect of the trend would necessarily be cumulative. The adoption of this process led to the conclusion that there is a small and regular increase in the percentage of T.P.N. from the fourth week until the end of the lactation, this increase being more pronounced towards the end of lactation.

Owing to the fact that "tests of significance, in so far as they are accurately carried out, are bound to agree" (S) whatever process of statistical analysis is employed, we attacked the problem from another/

another angle. The mean and the standard error of the mean of each column were computed, and $\pm$ double standard error was taken as a critical boundary, the corresponding values being plotted on graph paper. By this means, a "band" (i.e. the estimated 95% probability range of the means of columns) was obtained for the whole lactation-time. The trend of this "band" at different regions was in perfect agreement with the above conclusion. Table I of the appendix contains the number of entries, mean, standard error of the mean, and the values $\bar{m} - 2\sigma\bar{m}$ and $\bar{m} + 2\sigma\bar{m}$ for each column, and the "band" is shown in Figure 1.

(3) In comparing the lactation curves for the percentage of total protein nitrogen and for the yield of milk we observed that the variations of these two curves were generally in opposite directions (Fig. 2). This suggested that a study of the correlation between the yield and the percentage of T.P.N. and also of the variations of the amount of total protein nitrogen produced during the lactation time would be worth while.

The correlation coefficient between the yield and the percentage of T.P.N. determined for 368 samples of milk was:

$$r = -0.454 \pm 0.028 \qquad (1)$$

which is clearly significant.

Figure 3 shows the corresponding correlation table/

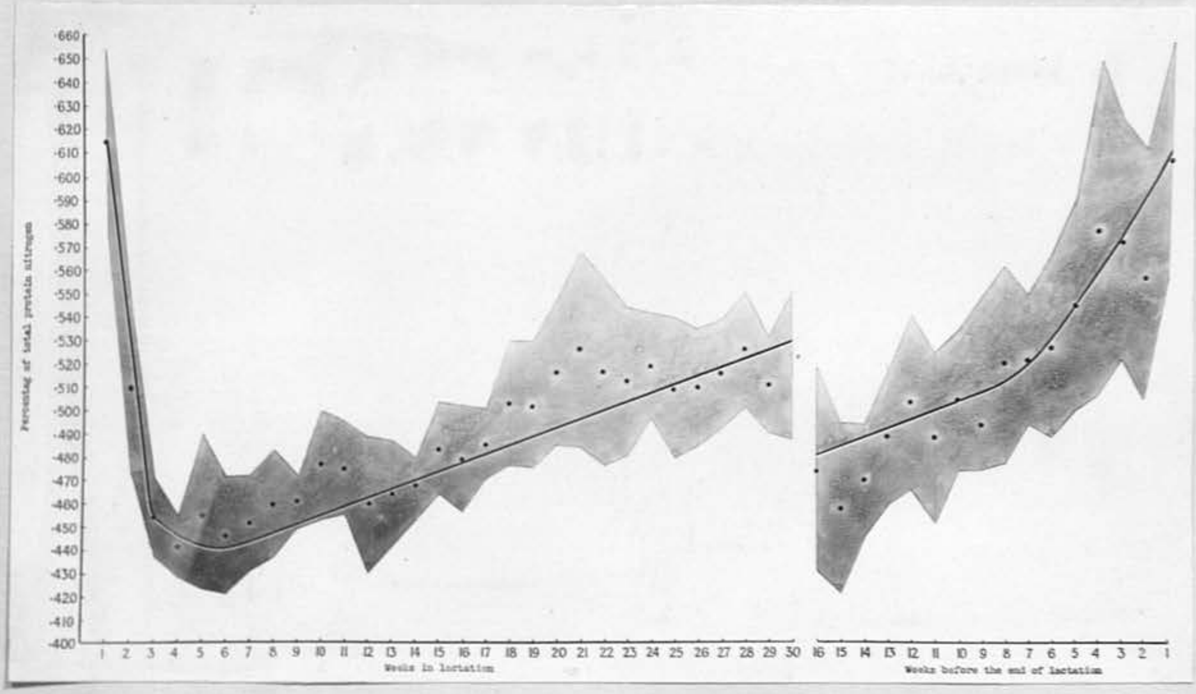

Fig. 1.

Showing the lactation curve for the percentage of total protein nitrogen. Each dot represents the mean value of the figures available for the corresponding week of lactation. The "band" shows the limits of $\bar{m} \pm 2\sigma\bar{m}$, i.e. the estimated 95 per cent. probability range of the mean values. The length of lactation being different for different cows, the lactation curve is studied in two sections corresponding to the first thirty and the last sixteen weeks of lactation.

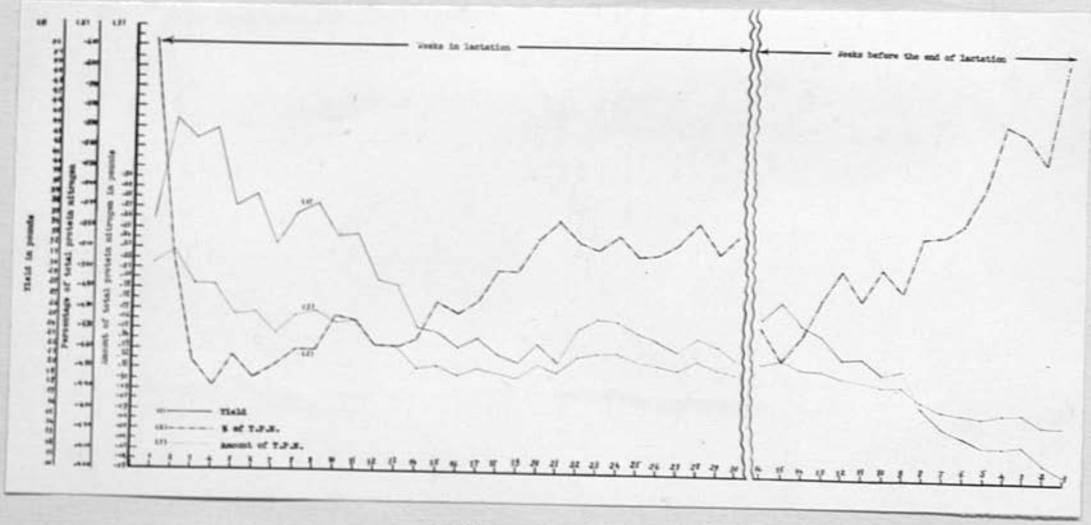

Fig. 2.

Showing lactation curves for the yield of milk (1), percentage (2) and the amount (3) of total protein nitrogen in 368 samples of milk taken from 27 individual cows at different stages of lactation. Ordinates of graphs (1) and (2) represent the mean values of the figures for all samples taken in each week of lactation. Ordinates of graph (3) are obtained by multiplying the corresponding ordinates of graphs (1) and (2).

table and regression lines. In this table the mean, the standard deviation, and the coefficient of variation are given for each variate.

The probable errors given in this table and all others are computed from Karl Pearson's tables (9).

It will be seen from this table:

(1) that the distribution is not normal for the two variates.

(2) that if the cow is a poor milker, an increase of one pound in yield of milk corresponds to a relatively high decrease in the % of T.P.N., whereas this decrease is much smaller if the cow is a good milker.

The amount of total protein nitrogen produced in each case was the product of milk yield and the corresponding % of T.P.N. The curve No. 3 (Figure 2) which represents the variations of these products shows a constant parallelism with the lactation curve for the yield in milk. This means that with a greater production of milk there is a greater production of proteins; and this in spite of the decrease observed when the proteins are expressed in terms of %.

The results of the study of the correlation between the yield and the amount of total protein nitrogen produced is in perfect agreement with the above conclusion. The correlation coefficient for the 363 samples of milk examined is:

r/

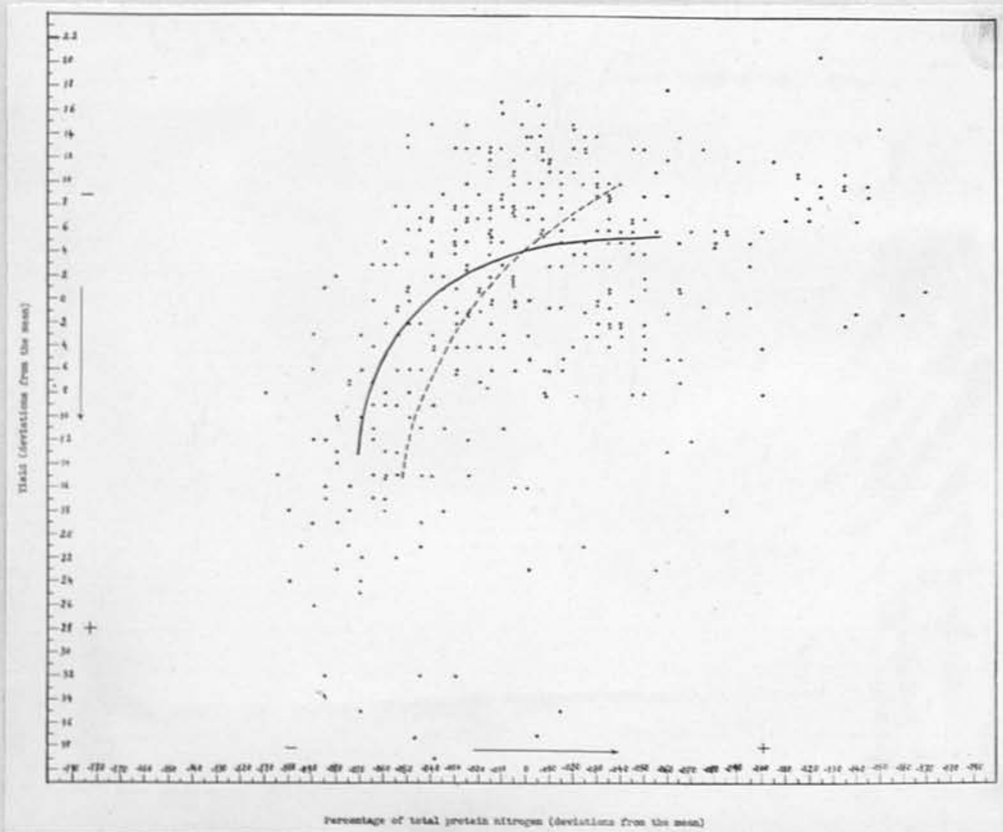

Fig. 3.

Showing the correlation between the yield of milk and the percentage of total protein nitrogen in 368 samples of milk taken from 27 individual cows at different stages of lactation. The arrows indicate the direction in which each variate increases. The curve ______ represents the regression line of the percentage of total protein nitrogen on the yield of milk. The curve ------- represents the regression line of the yield of milk on the percentage of total protein nitrogen. The following statistics indicate the details concerning each variate:

	Yield of milk (lbs.)	% of T.P.N.
Mean	25.35 ± 0.39	0.5095 ± 0.0019
Standard deviation	10.98 ± 0.27	0.0555 ± 0.0014
Coefficient of variation	43.3 ± 1.26	10.8 ± 0.3

Correlation coefficient $r = -0.454 \pm 0.028$

$$r = 0.951 \pm 0.003 \qquad (2)$$

which is very high.

The two regression coefficients are:

*Regression of milk yield on the amount of T.P.N.:

$$0.951 \times \frac{10.98}{50.3} = 0.207 \qquad (3)$$

*Regression of the amount of T.P.N. on yield:

$$0.951 \times \frac{50.3}{10.98} = 4.35 \qquad (4)$$

The equation (3) means that for an increase of 453.59 grams (one pound) in milk there is an increase of about .2 milligrams in the amount of total protein nitrogen.

Further equation (4) shows that if the amount of T.P.N. rises by one milligram, there will be an increase of about 4.35 pounds in the yield of milk.

The fact that an increase in yield of milk means an increase in the amount of total protein, and also that an increase in the latter corresponds to an increase in the yield of milk, is of physiological and economical importance. It shows that the synthesis of proteins in milk is not an independent process, but is closely related to the synthesis of the milk itself. In other words it would be impossible to get cows to produce a milk with a

*These two regression lines are assumed to be linear. This assumption is not very far from the truth for practical purposes, for all the dots are placed within a narrow band.

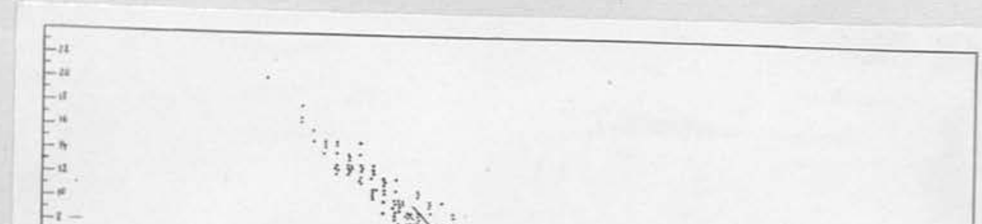

Fig. 4.

Showing the correlation between the yield of milk and the yield of total protein nitrogen in 368 samples of milk taken from 27 individual cows at different stages of lactation. The arrows indicate the direction in which each variate increases. The curve ______ represents the regression line of the yield of milk on the yield of total protein nitrogen. The curve ----- represents the regression line of the yield of total protein nitrogen on the yield of milk. These two curves are not linear; but in the section indicated on the graph they are very near to straight line and may be assumed to be so for practical purposes.

The following statistics indicate the details concerning each variate.

	Yield of milk (lbs.)	Yield of T.P.N. (1/1000ths of lb.)
Mean	25.35 ± 0.39	126.3 ± 1.8
Standard deviation	10.98 ± 0.27	50.3 ± 1.2
Coefficient of variation	43.3 ± 1.26	39.8 ± 1.14

Correlation coefficient $r = 0.951 \pm 0.003$

very low or a very high protein content.

Morris & Wright have studied the biological value of various protein-foods for milk production and have come to the conclusion that those containing a relatively high content of lysine and triptophane are more adequate for milk production than others, since the milk itself contains a large amount of these amino-acids and the animal organism cannot produce them (10).

From the conclusion reached above it appears that if the amount of protein in the ration is diminished to such extent as to exhaust the body protein reserve, the result would be not a milk poorer in protein, but a smaller quantity of milk (equation 2), richer in protein (equation 1).

On the other hand, an increase in the amount of protein in the food would increase the yield if the production of milk were below its maximum level, otherwise it would not make any difference either in the yield or in the % of protein in milk.

Perkins (11), Morris (12), and Turner (13) have studied in carefully designed experiments the influence of the amount of protein in food on the yields and on the chemical composition of milk, and their results are in perfect agreement with the above conclusions. Of special interest in this respect is/

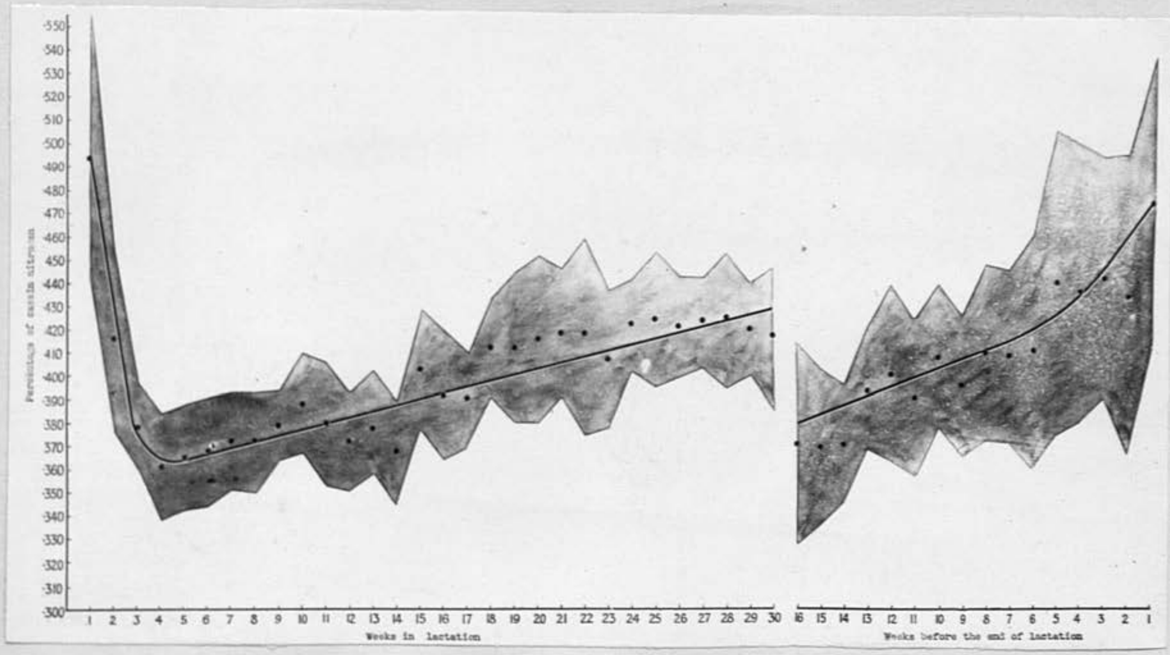

Fig. 5.

Showing the lactation curve for the percentage of casein nitrogen. Each dot represents the mean value of all figures available for the mean value of all figures available for the corresponding week of lactation. The "band" shows the limits of $\bar{m} \pm 2\delta\bar{m}$, i.e. the estimated 95% probability range of the mean values.

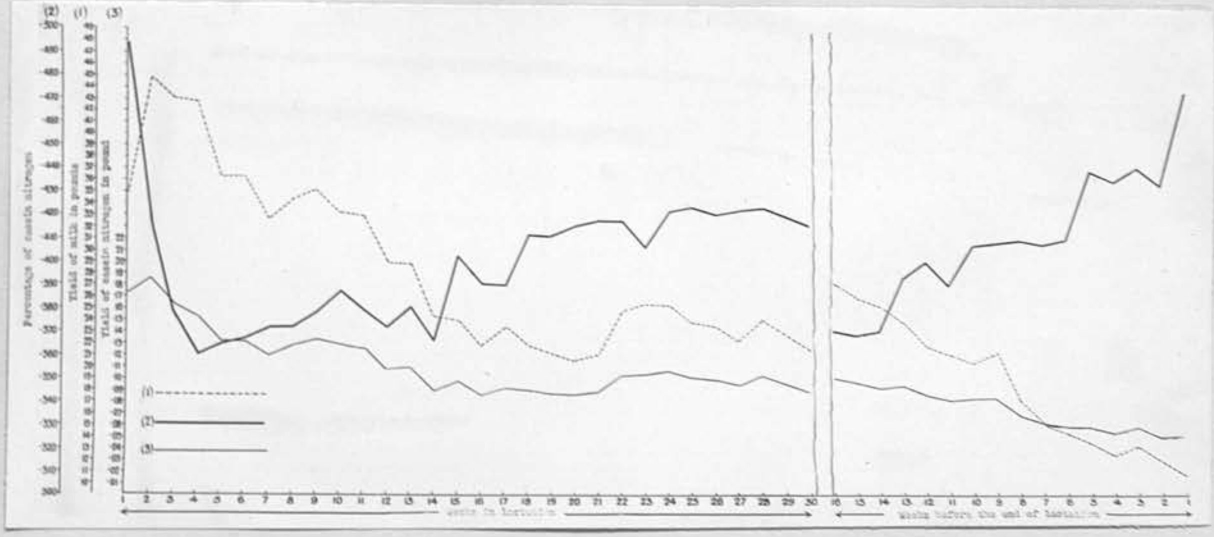

Fig. 6.

Showing lactation curves for the yield of milk (1), percentage (2) and the amount (3) of casein nitrogen (363 samples). Ordinates of graphs (1) and (2) represent the mean values of all the figures corresponding to samples taken in each week of lactation. Ordinates of graph (3) are obtained by multiplying the corresponding ordinates of graphs (1) and (2).

is the work of Gowen et al. (14). They studied the variations which occurred in the yield and in the composition of the milk of cows receiving no food but having access to as much water as they wished. They observed a progressive and marked decrease in the yield and in the % of lactose, and an increase in fat, ash, and protein.

During the present investigation, the writer has also observed an increase in the % of T.P.N. in the milk of cows whose yield fell during sexual excitement. It is noteworthy that from the analysis of the results of this investigation, which was not concerned with rationing, it has been possible to arrive at the same conclusions as those reached by other investigators who have carried out experiments on the feeding of cattle.

B) Casein nitrogen. The C.N. forms about 77% of the T.P.N. in milk (15) and the above discussion on T.P.N. was found to be applicable to the C.N. The same methods of statistical analysis and tests of significance were used and the following results were obtained:

(1) Lactation curve for the percentage of C.N. (Fig. 5) with the corresponding table (No. 2 appendix) containing details of 95% probability range of the estimation of meansof columns.

(2)/

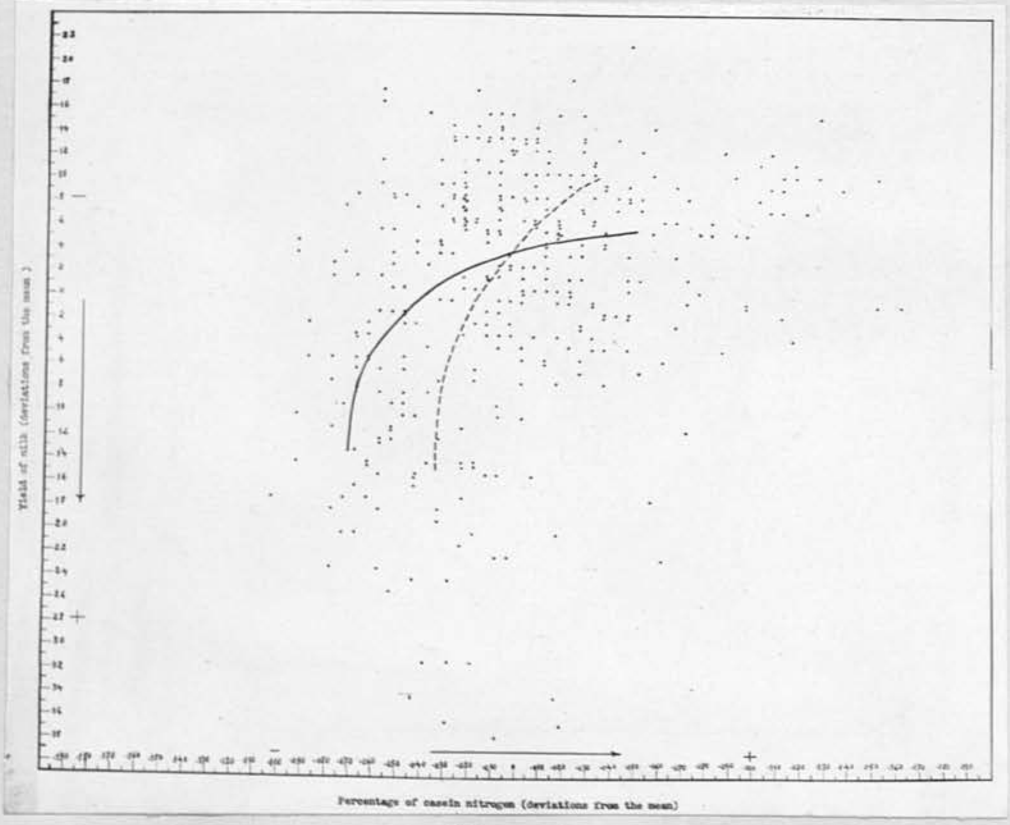

Fig. 7.

Showing the correlation between yield of milk and percentage of casein nitrogen in 363 samples of milk. The arrows indicate the direction in which each variate increases. The curve ______ represents the regression line of the percentage of casein nitrogen on the yield of milk. The curve ------ represents the regression line of the yield of milk on the percentage of total protein nitrogen. The following statistics indicate the details concerning each variate:

	Yield of Milk (lbs.)	% of C.N.
Mean	25.15 ± 0.39	0.4119 ± 0.0018
Standard deviation	11.03 ± 0.28	0.0511 ± 0.0013
Coefficient of variation	43.8 ± 1.3	12.3 ± 0.3

Correlation coefficient $r = -0.318 \pm 0.031$

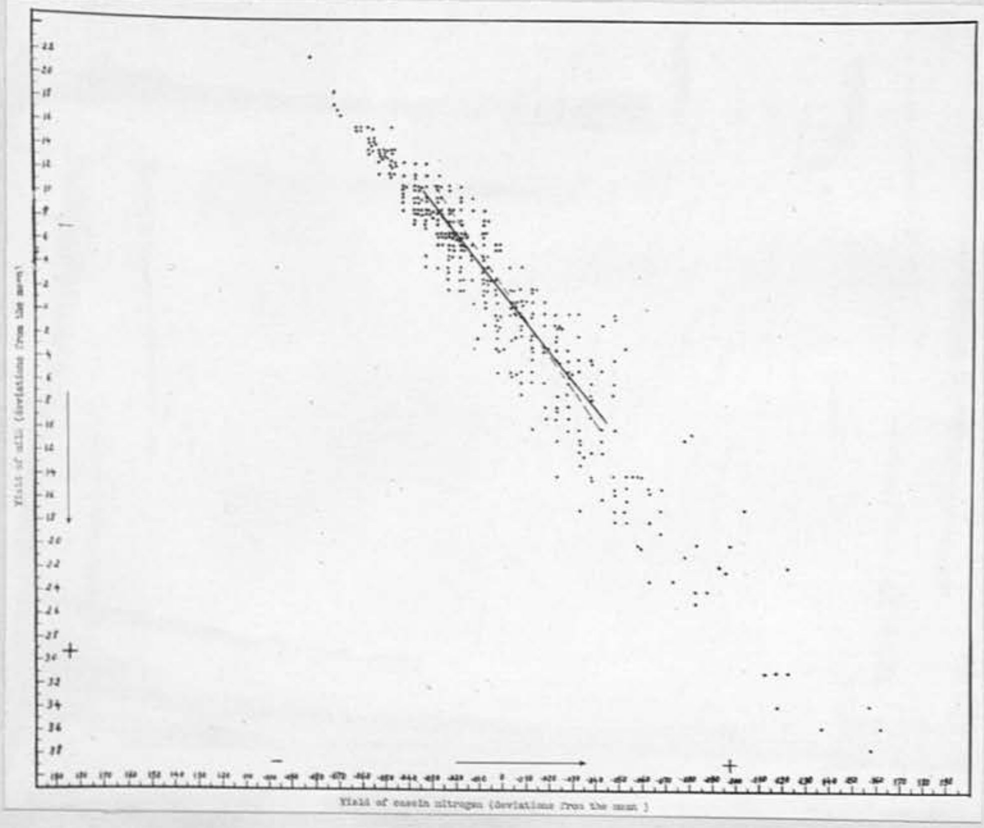

Fig. 8.

Showing correlation between the yield of milk and the yield of casein nitrogen in 368 samples of milk taken from 27 individual cows. The arrows indicate the direction in which each variate increases. The curve _____ represents the regression line of the yield of casein nitrogen on the yield of milk. The curve ----- represents the regression line of the yield of milk on the yield of casein nitrogen. The two curves are not linear but are very near to straight line. The following statistics indicate details concerning each variate.

	Yield of Milk (lbs.)	Yield of C.N. (1/1000ths of lb.)
Mean	25.15 ± 0.39	101.9 ± 1.5
Standard deviation	11.03 ± 0.28	41.9 ± 1.04
Coefficient of variation	43.8 ± 1.3	41.1 ± 1.2

Correlation coefficient $r = 0.927 \pm 0.0049$

(2) Lactation curve for the amount of C.N. (Fig. 6).

(3) Correlation coefficient between yield and the % of C.N. was: $r = -0.318 \pm 0.031$.

Tocher (16) working with a different material (474 samples from one milking of 474 cows scattered over the whole area of Scotland, and over a whole year), and with a different method of chemical analysis has found a higher value, i.e. -.4219.

(4) Correlation coefficient between the yield of milk and the yield of C.N. was:

$$r = 0.927 \pm .0049$$

and the regression equations:

$$*R\ \frac{\text{yield of milk}}{\text{yield of C.N.}} = 0.927 \times \frac{11.03}{41.9} = 0.244$$

$$*R\ \frac{\text{yield of C.N.}}{\text{yield of milk}} = 0.927 \times \frac{41.9}{11.03} = 3.521$$

The Figs. (7) and (8) show the corresponding correlation tables with the details concerning each variate.

C) Albumin and globulin nitrogen.

(1) The lactation curve (Fig. 9) for the % of A.+ G.N. is of the same general trend as for the C.N., although the trend for the former is much smaller than for the latter.

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*See note at foot of page 24.

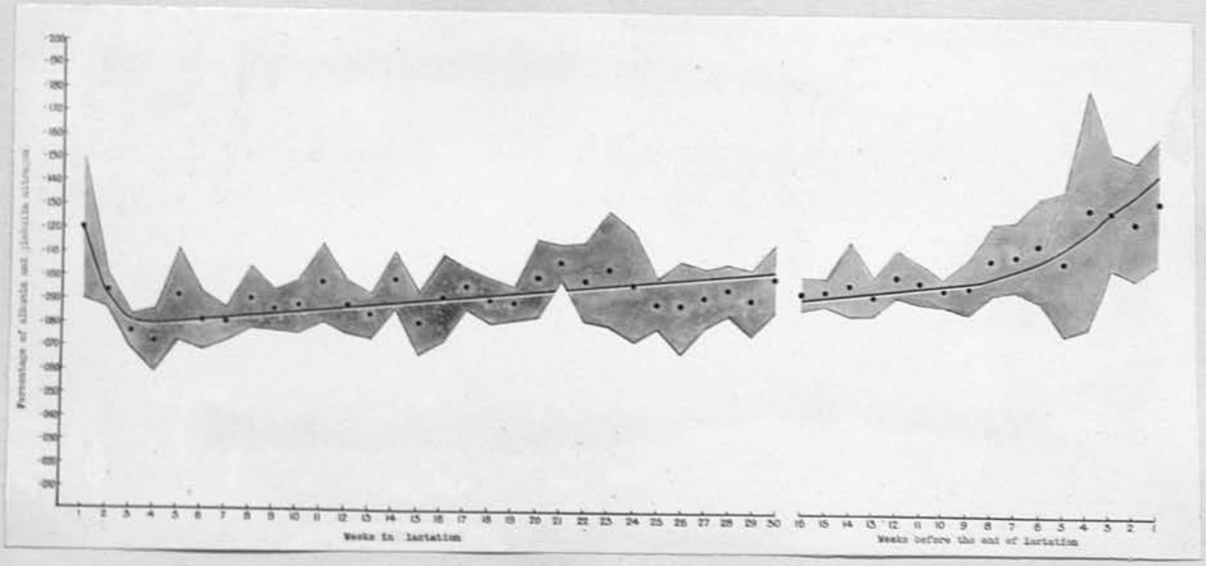

Fig. 9.

Showing lactation curve for the percentage of albumin and globulin nitrogen. Each dot represents the mean value of all the figures available for the corresponding week of lactation. The "band" shows the limits of $\bar{m} \pm 2\delta m$, i.e. the estimated 95% probability range of the mean values.

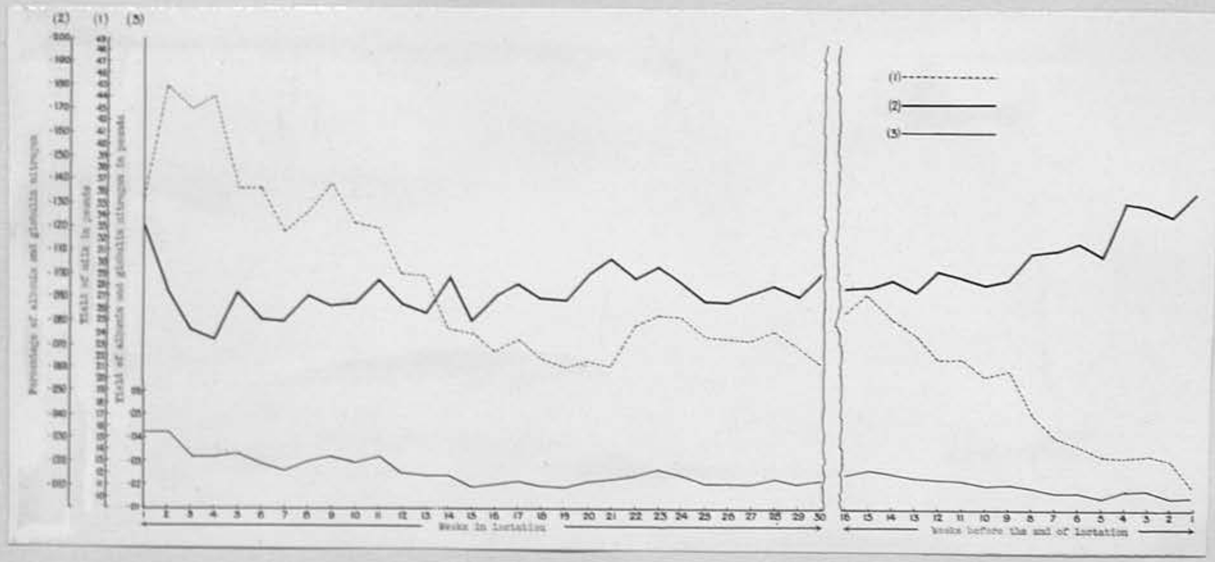

Fig. 10.

Showing lactation curves for the yield of milk (1), the percentage (2) and the amount (3) of albumin and globulin nitrogen (356 samples). Ordinates of graphs (1) and (2) represent the mean values of the figures for all samples taken in each week of lactation. Ordinates of graph (3) are obtained by multiplying the corresponding ordinates of graphs (1) and (2).

(2) The lactation curve for the amount of albumin and globulin nitrogen is given in Fig. 10.

(3) The correlation table (Fig. 11) between the yield of milk and the % of A. + G.N. shows that the distribution is very different from that of the C.N. The coefficient of variability is also much larger than for the C.N. The correlation coefficient is:

$$r = -.274 \pm .033$$

Tocher, with the same material as mentioned above, found r = -.2948.

(4) The correlation table (Fig. 12) for the yield of milk and the yield of A.+ G.N. shows a much more scattered distribution than in the case of C.N. The correlation coefficient is:

$$r = 0.797 \pm 0.013$$

Discussions.

1) Bartlett (17) in a study of the "Variations in the Solids-not-Fat Content of Milk" states in referring to "about 40 days after calving" that "for several months after this time the composition of the milk tends to be remarkably constant". The conclusions drawn from the present work do not support however the above statement. Tocher (16) has shown that there exists a positive and significant correlation between the yield of milk and the % of lactose/

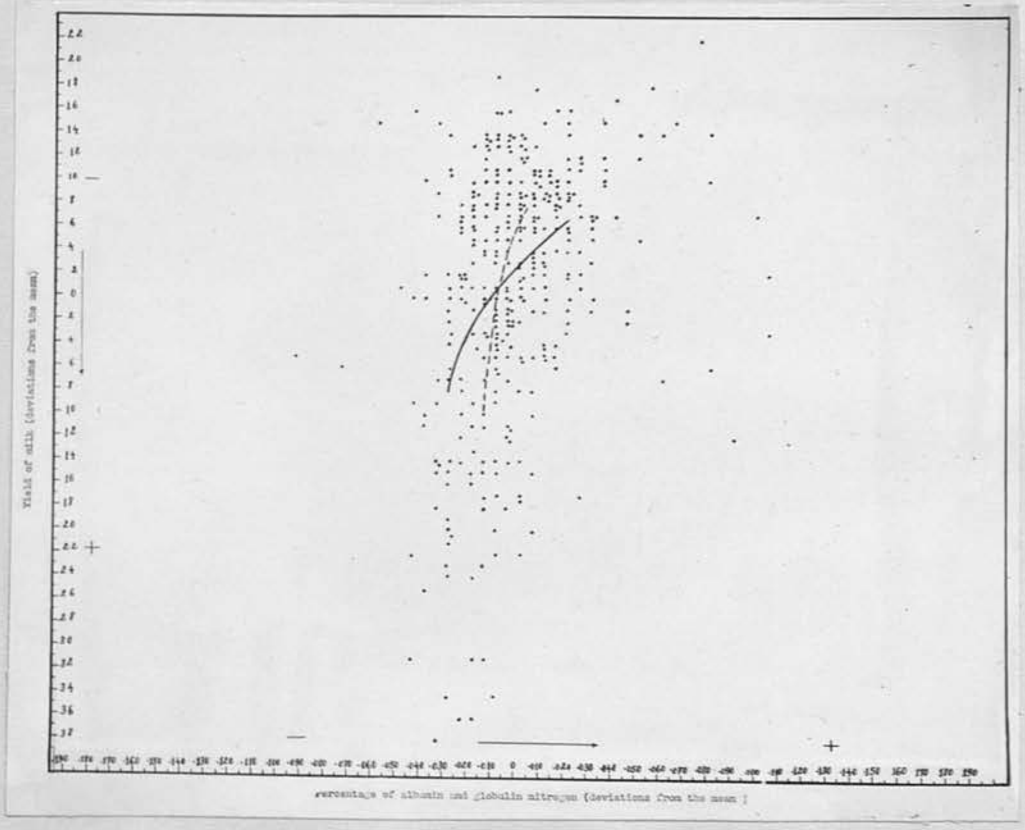

Fig. 11.

Showing correlation between the yield of milk and the percentage of albumin and globulin nitrogen (356 samples). The arrows indicate the direction in which each variate increases. The curve _____ represents the regression line of the percentage of albumin and globulin nitrogen on the yield of milk. The curve ----- represents the regression line of the yield of milk on the percentage of albumin and globulin nitrogen. The following statistics indicate the details concerning each variate:-

	Yield of Milk (lbs.)	% of A. + G.N.
Mean	25.26 ± 0.38	0.0973 ± 0.0011
Standard deviation	10.86 ± 0.27	0.0302 ± 0.0007
Coefficient of Variation	43 ± 1.27	31 ± 0.85

Correlation coefficient $r = -0.274 \pm 0.033$

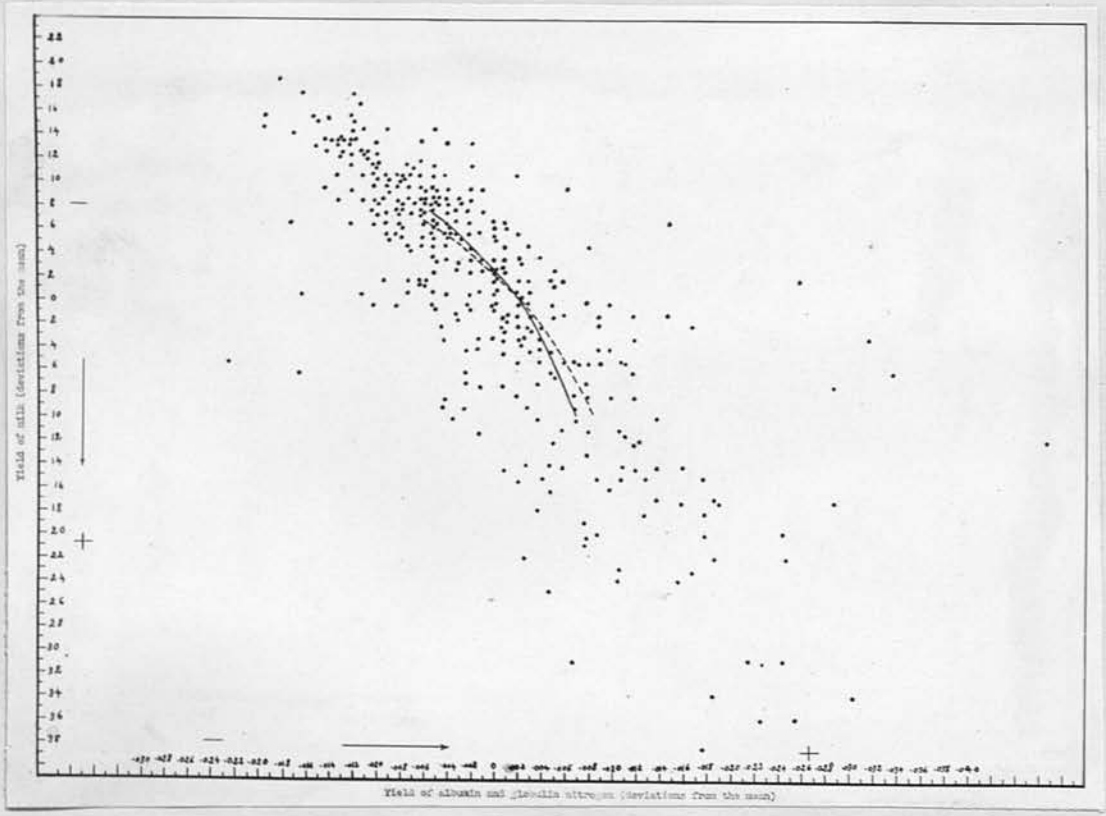

Fig. 12.

Showing correlation between the yield of milk and the yield of albumin and globulin nitrogen (356 samples). The arrows indicate the direction in which each variate increases. The curve _____ represents the regression line of the yield of milk on the yield of albumin and globulin nitrogen. The curve ------ represents the regression line of the yield of albumin and globulin nitrogen on the yield of milk. The following statistics indicate details concerning each variate.

	Yield of Milk (lbs.)	Yield of A. + G.N. (1/1000ths lb.)
Mean	25.26 ± 0.38	23.6 ± 0.36
Standard deviation	10.86 ± 0.27	10.14 ± 0.27
Coefficient of variation	43 ± 1.27	42.96 ± 1.27

Correlation coefficient $r = 0.797 \pm 0.013$

lactose. Since the yield of milk decreases regularly "from about 40 days after calving" towards the end of lactation, one must conclude that the % of lactose decreases also in the same direction. The fact observed by Bartlett that the Solids-not-Fat content of milk remains constant during several months does not mean necessarily that the composition of the milk is also "remarkably constant " during that time. All we can conclude is that the decrease in the % of lactose is counterbalanced by the increase in the % of proteins, and ash (Tocher) in such a way that the % of Solids-not-Fat remains constant.

(2) It is necessary to bear in mind that the facts observed and the conclusions drawn in the present investigation are of a relative value and by no means strictly applicable to individual cows. In fact, this work like most of the investigations in biological sciences, is based upon principles which themselves are of a relative value. Consequently the results obtained do not necessarily represent the absolute truth as in pure sciences.

The present state of knowledge about the chemistry of casein is very limited. In precipitating casein by Moir's method it is supposed that all the samples of milk have the same initial PH. This is not true, since variability is one of the most important characteristics of the living organisms, and/

and as Ducleux pointed out: "Il n'ya pas "du lait" mais bien "des laits"" (18).

Further it must be remembered that the principles of statistics are based upon the "law of large populations which "suivant l'expression d'un grand mathematicien est toujours vraie en général et fausse en particulier" (19). For instance just as the length of lactation is different with various cows, the time in which the % of various proteins in milk decreases may be different from cow to cow and last from 3 to 6 weeks according to the breed of the cow and other factors.

3) Actually from a purely scientific standpoint, this work is no more than a record of a number of measurements from which certain conclusions are drawn. It does not tell us anything about the real causes of the variations observed. It would have been more interesting if it had explained their causes and established their relations with the whole harmonic set of phenomena which contribute to form the unity of life.

Owing to the exceptional conditions under which the experimental herds are kept, it is probable that the average herd would show somewhat greater variation, and studies of the comparisons of yields of animals from several herds would show still greater variation/

variation owing to differences in nutrition and other environmental factors.

Summary.

(1) It was planned to study the variations of the protein content of milk during the lactation period.

(2) The total protein nitrogen and the casein nitrogen were determined by approved methods in about 380 weekly samples of milk taken from 27 individual cows of different breeds and at different stages of lactation, from February to July, 1937. The albumin plus globulin N. was calculated in each case by difference.

(3) The statistical analysis of the figures was made by the methods of "factorial arrangement", and "pairing" and also by the estimation of the 95% probability range of the mean of the figures available for each week of lactation.

(4) It was found that the % of T.P.N. decreases very significantly from the beginning until the 4th week of lactation, and then rises slowly until the end of lactation, the rise being more pronounced towards the end. The same was true for C.N. and for A. + G.N., but in the case of the latter only the decrease at the beginning and/

and the rise at the end were sharp. The rise for the rest of the lactation curve, although it did exist, was very slow.

(5) The lactation curves for the yield of T.P.N., C.N. and A. + G.N. were practically parallel with the lactation curve for the yield of milk.

(6) The correlations between the yield of milk and the percentages of T.P.N., C.N., and A. + G.N. are studied and the correlation tables with all details are given for each case. It is noteworthy that the regression lines are not linear and that with a poor milker an increase of one pound in yield of milk corresponds to a relatively high decrease in the % of P.N., whereas with a high milker this decrease is relatively much smaller.

(7) The correlations between the yield of milk and the yield of T.P.N., C.N., and A. + G.N. are examined and the correlation tables are given. It is shown that there is a close correlation between the yield of milk and its protein content, from which the conclusion is drawn that a very low protein food does not decrease the % of protein in milk as one might expect, but decreases the yield of milk and increases the % of protein in milk. On the other hand an increase of adequate protein in the ration may raise the yield of milk if it is not at its maximum/

maximum level.

(8) It is emphasised that the above conclusions are drawn from a study carried out on a group of cows, and may not be strictly applicable to individual cows.

Acknowledgments.

The writer wishes to acknowledge his gratitude to Professor F.A.E. Crew for the hospitality and facilities received at the Institute of Animal Genetics during this investigation. He also wishes to express his indebtedness to Mr A. D. Buchanan Smith and Dr A. M. Smith for their valuable help, encouragement and criticism throughout the work. His sincere thanks are also due to Professor R. A. Fisher and Dr A. C. Aitken for their helpful assistance and advice during the statistical analysis of the work.

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APPENDIX.

Table 1. Total Protein Nitrogen.

Estimation of 95% probability range of the mean of the figures available for each week of lactation.

n = number of cows. $\bar{m}$ = mean. $\sigma\bar{m}$ = standard error of the mean

Week	n	$\sigma\bar{m}$	$\bar{m}-2\sigma\bar{m}$	$\bar{m}$	$\bar{m}+2\sigma\bar{m}$
1	4	20.42	573.2	614	654.8
2	4	18.36	472.8	509.5	546.2
3	6	8.43	437.6	454.5	471.4
4	5	6.74	428.1	441.6	455.1
5	8	16.80	423.4	457	490.6
6	9	12.88	420.7	446.5	472.3
7	8	10.48	430.7	451.7	472.7
8	10	11.62	437.1	460.4	483.6
9	9	5.19	449.8	468.2	470.6
10	10	11.73	453.3	476.8	500.3
11	11	9.98	455.5	475.5	495.5
12	9	14.56	430.5	459.6	488.7
13	8	11.52	441.1	464.1	487.1
14	6	6.82	452.5	466.1	479.7
15	8	9.91	463.9	483.7	503.5
16	7	11.53	456.2	479.3	502.3
17	8	7.78	469.8	485.4	501
18	8	13.30	476.4	503	529.6
19	6	14.18	473.6	502	530.4
20	7	15.40	485.5	516.3	547.1
21	10	21.18	483.3	525.7	568.1
22	10	19.92	476.2	516.1	555.9
23	10	15.97	480.3	512.3	544.2
24	11	11.62	496	519.3	542.5
25	11	15.19	478.8	509.2	539.6
26	12	12.68	484.6	510	535.4
27	12	11.59	492.5	515.7	538.9
28	11	12.54	501.3	526.4	551.4
29	11	10.44	490	510.9	531.8
30	11	15.78	488	519.6	551.2
Wks. before end of lactation.					
16	6	21.95	430.7	474.6	518.5
15	6	18.4	421.5	458.3	495.1
14	8	12.3	445.6	470.2	494.8
13	8	14.71	459.4	488.8	518.2
12	9	18.83	466.1	503.8	541.5
11	9	18.6	451.4	488.6	525.8
10	10	15.19	474.3	504.7	535.1
9	9	9.87	474.5	494.3	514
8	7	21.6	477.5	520.7	563.9
7	7	14.43	493.6	522.5	551.4
6	7	19.87	488.5	528.2	567.9
5	5	23.1	499.8	546	592.2
4	3	35.91	506.2	578	649.8
3	6	25.62	521.8	573	624.2
2	6	26.68	504.7	558.1	611.5
1	5	25.76	557.9	609	660.5

Table 2. <u>Casein Nitrogen.</u>

Estimation of 95% probability range of the mean of the figures available for each week of lactation.

n = number of cows. $\bar{m}$ = mean. $\sigma\bar{m}$ = standard error of the mean.

Weeks in Lactation	n	$\sigma\bar{m}$	$\bar{m}-2\sigma\bar{m}$	$\bar{m}$	$\bar{m}+2\sigma\bar{m}$
1	4	25.9	442.2	494	545.8
2	4	19.9	375.95	415.75	455.55
3	6	9.2	360.1	378.5	396.9
4	6	11.4	338.03	360.83	383.63
5	8	11.7	341.6	365	388.4
6	8	11.7	344.22	367.62	391.02
7	9	10.5	350.62	371.62	392.62
8	9	10.9	349.6	371.4	393.2
9	10	7.3	364.4	379	393.6
10	10	10.7	367	388.4	409.8
11	10	13.5	353.3	380.3	407.3
12	9	10.5	351.2	372.2	393.2
13	8	11.2	358.22	380.62	403.02
14	6	10.8	345.4	367	388.6
15	8	13.2	376.6	403	429.4
16	8	13.7	363.97	391.37	418.77
17	8	10.3	369.27	389.87	410.47
18	8	10.9	390.7	412.5	434.3
19	5	16.3	379.9	412.5	445.1
20	7	18.1	379.8	416	452.2
21	10	13.6	391.2	418.4	445.6
22	10	20.7	376.2	417.6	459
23	10	14.9	377.9	407.7	437.5
24	11	10	401.81	421.81	441.81
25	10	14.3	395.4	424	452.6
26	12	11.1	399.1	421.3	443.5
27	12	10.2	402.68	423.08	443.48
28	10	14.5	395.4	424.4	453.4
29	11	10	399.9	419.9	439.9
30	10	15.4	385.2	416	445.8
Wks. before end of lactation.					
16	7	22.2	326.6	371	415.4
15	7	16.7	336	369.4	402.8
14	8	12.1	357.3	371.5	395.7
13	8	13.4	367.8	394.6	421.4
12	9	19	363	401	439
11	10	16.7	357.4	390.8	424.2
10	10	15.6	376.7	407.9	439.1
9	9	15.4	364.7	395.5	426.3
8	7	19	372	410	448
7	6	18.7	371.2	408.6	446
6	6	25.1	360.4	410.6	460.8
5	4	33.2	373.6	440	506.4
4	4	27.9	379.9	435.7	491.5
3	6	26.2	389.6	442	494.4
2	6	32.3	366.2	430.8	495.4
1	5	30.5	412.6	473.6	534.6

Table 3. <u>Albumin nitrogen + globulin nitrogen.</u>

Estimation of 95% probability range of the mean of the figures available for each week of lactation.

n = number of cows. $\bar{m}$ = mean. $\sigma\bar{m}$ = standard error of the mean.

Week	n	$\sigma\bar{m}$	$\bar{m}-2\sigma\bar{m}$	$\bar{m}$	$\bar{m}+2\sigma\bar{m}$
1	4	14.7	90.3	119.7	149.1
2	4	3.2	86.85	93.25	99.65
3	6	3.7	68.6	76	83.4
4	5	6.9	58.6	72.4	86.2
5	8	9.4	73.45	92.25	111.05
6	8	6	69	81	93
7	8	3.4	73.2	80	86.8
8	9	6.3	78.4	91	103.6
9	9	4	78.2	86.2	94.2
10	10	5.6	76.8	88	99.2
11	10	8.2	81.2	97.6	114
12	9	5.3	76.4	87	97.6
13	8	4.9	73.82	83.62	93.42
14	6	5.8	87.2	99	110.8
15	8	6.7	67.1	80.5	93.9
16	7	9	73.42	91.42	109.42
17	8	4.3	87.02	95.62	104.02
18	8	4.9	80.7	90.5	100.3
19	5	3.7	81.8	89.2	96.6
20	6	8.2	83.76	100.16	116.56
21	10	3.7	100	107.4	114.8
22	11	8.4	82.01	98.81	115.61
23	10	12.4	79.9	104.7	129.5
24	11	11.8	73.76	97.36	120.96
25	10	5.1	79.2	89.4	99.6
26	12	9.6	69.3	88.5	107.7
27	12	6.2	80.1	92.5	104.9
28	10	5.2	85.9	96.3	106.7
29	11	7.1	76.89	91.09	105.29
30	10	7.3	86.7	101.3	115.9
Wks. before end of lactation.					
16	6	3.6	87.9	95.1	102.3
15	6	2.9	90.3	96.1	101.9
14	8	6.4	86	98.8	111.6
13	8	3.9	86.4	94.2	102
12	9	4.4	93.8	102.6	111.4
11	9	4.4	91.3	100.1	108.9
10	10	3.1	90.4	96.6	102.8
9	9	6.1	86.8	99	111.2
8	7	7.5	95.5	110.5	125.5
7	6	7.5	96.8	111.8	126.8
6	6	11.2	92.7	115.1	137.5
5	4	15.5	78.5	109.5	140.5
4	3	25.4	81.2	132	182.8
3	6	12.3	106.4	131	155.6
2	6	12.8	101.7	127.3	152.9
1	5	13.4	109	135.8	162.6

"ERRORS INVOLVED IN THE ESTIMATION OF LACTATION YIELD OF PROTEIN, IF TWO OR THREE WEEKLY SAMPLES ARE TAKEN INSTEAD OF WEEKLY ONES."

by

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Contents.

"When you can measure what
you are speaking about
and express it in numbers,
you know something about
it, but when you cannot
measure it, when you cannot
express it in numbers, your
knowledge is of a meagre
and unsatisfactory kind."

Lord Kelvin.

Introduction.

A series of investigations was designed to study whether the protein content of cow's milk is a hereditary character. For this purpose, it was necessary to have data on a large number of cows for several lactations. This meant a large number of analyses for each cow; and since the determination of protein in milk is a laborious process, it was desirable to reduce the number of analyses for each animal as far as this could be done consistently with accuracy. Owing to the lack of precise data on the variations of protein content of milk during lactation, it was necessary to carry out a preliminary study, to determine the maximum adequate interval between two successive analyses of the milk of the same cow. This preliminary study was carried out during the years 1936-1937 and the results of the chemical part of it are described elsewhere. The object of the present study is to analyse the data/

data statistically and to determine whether it is possible to take fortnightly or three weekly samples instead of weekly ones without disturbing unduly the accuracy of the results.

Material and method.

Variations in protein yield of a cow are due to changes both in her yield of milk and in the percentage of protein in her milk.

If it were possible to have for each day of lactation, figures for the yield of milk and its percentage of protein, the estimation of lactation yield of protein would be easy, but in practice this is not possible since the determination of protein in milk is a long and laborious process.

In measuring the yield and the protein content of milk at intervals and taking the figures obtained each time as averages for a whole interval, errors will necessarily be introduced in the estimation of lactation yield of protein. These errors will be due partly to changes in the yield of milk and partly to changes in its protein content. Those due to the former cause may be eliminated if the daily yields of milk are measured, and the results used in the calculation of protein yield.

The present investigation (which is to be used as a basis in a series of experiments on cows whose milks/

milks are weighed daily) is concerned only with errors due to variations in the protein content.

The material used in this investigation has already been described (1). It is based on the results of analysesof 380 daily samples of milk taken from 27 cows in different stages of lactation at intervals of 7 days. Tocher (2) has shown that in milk the coefficient of variation for casein is much smaller than that for albumin which, in turn, is similar to that for fat. As weekly samples are considered sufficiently reliable for the estimation of total yield of fat, the same was assumed to be true in the case of total protein nitrogen.

The method adopted in this investigation for testing the accuracy of fortnightly, as against weekly measurement, is based on the degree of error involved in a single test compared with the mean of two consecutive tests, one of which is the figure used for the single test. Likewise, the accuracy of determinationsmade at intervals of three weeks is obtained by examination of the degree of error involved in a single test compared with the mean of three consecutive tests, one of which is the figure used for the single test. If the mean is taken as equal to 100, then the error of the single figure can be expressed as a percentage of the mean. When a large number of consecutive figures are treated/

treated in this manner, a "population" of errors is obtained. The mean of this "population" is zero, and its standard deviation gives the limits within which 68% of the "population" is found.

For the test of the fortnightly determinations, 50 pairs of two consecutive determinations were taken at random from the data, at least one being included from each of the cows whose milk had been tested (except cow No. 27 whose milk was tested only two times). To test the accuracy of three weekly determinations, 34 groups of three consecutive figures were taken again at random, including all the cows, except cows Nos. 26 and 27. Tables (1) and (2) show the results and the details of calculation of the standard deviation in each set. For fortnightly determinations, the standard deviation is = ± 2.92. This means that, by taking weekly samples as the basis of comparison, the use of fortnightly samples will involve errors which will be found within the limits of ± 2.92% 68 times out of 100, and 95 times out of 100 they will be found within the limits of ± 5.84. In the case of three weekly samples, the standard deviation is slightly greater, i.e. 2.99%, and 95% of errors will fall within the limits of ± 5.98%.

TABLE 1.

Estimation of the errors involved in the determination of lactation yield of protein when two weekly samples are taken instead of weekly ones, and when the true yields of milk are used in the calculation of protein yield.

Cow No.	Milligrams of total protein nitrogen in 100 grams of milk.	Means	d (Absolute values of the differences from the means.)	D (d expressed as % of mean.)	D^2
1	421 427	424	3 3	.71 .71	.5041 same
	471 463	467	4	.09	.0081 s.
2	512 437	474.5	37.5	7.91	62.5681 s.
	453 470	461.5	8.5	1.84	3.3856 s.
3	563 480	521.5	41.5	7.97	63.5209 s.
	468 460	464	4	.86	.7396 s.
4	464 460	462	2	.43	.1849 s.
	462 451	456.5	5.5	1.2	1.44 s.
5	420 450	435	15	3.45	11.9025 s.
	433 503	468	35	7.49	56.1001 s.
6	488 476	482	6	1.24	1.5376 s.
	480 461	470.5	9.5	2.01	4.0401 s.
	509 528	518.5	9.5	1.83	3.3489 s.
7	457 460	458.5	1.5	.33	.1089 s.
	484 505	494.5	10.5	2.12	4.4944 s.

Table 1 (contd.)

Cow No.	Milligrams of total protein nitrogen in 100 grams of milk.	Means	d (Absolute values of the differences from the means.)	D (d expressed as % of mean.)	D^2
8	572 530	551	21	3.8	14.44 s.
	496 519	507.5	11.5	2.26	5.1076 s.
9	432 448	440	8	1.81	3.2761 s.
10	436 448	442	6	1.36	1.8496 s.
	492 494	493	1	.20	.04 s.
11	417 450	433.5	16.5	3.81	14.5161 s.
12	486 508	497	11	2.20	4.84 s.
	470 484	477	7	1.46	2.1316 s.
13	513 472	492.5	20.5	4.16	17.3056
	457 460	458.5	1.5	.33	.1089 s.
14	679 585	632	47	7.43	55.2049 s.
	545 545	545	0	0	0 s.
15	468 495	481.5	13.5	2.79	7.7841 s.
	479 533	506	27	5.35	28.6225 s.
	465 492	478.5	13.5	2.82	7.9524 s.
16	496 489	492.5	3.5	.71	.5041 s.
	500 529	514.5	14.5	2.81	7.8961 s.

Table 1 (contd.)

Cow No.	Milligrams of total protein nitrogen in 100 grams of milk.	Means	d (Absolute values of the differences from the means.)	D (d expressed as % of mean.)	D^2
17	524 505	514.5	9.5	1.84	3.3856 s.
	500 507	503.5	3.5	.70	.49 s.
18	448 460	454	6	1.32	1.7424 s.
	438 435	436.5	1.5	.34	.1156 s.
19	555 542	548.5	6.5	1.18	1.3924 s.
	547 566	556.5	9.5	1.7	2.89 s.
20	527 522	524.5	2.5	.47	.2209 s.
	538 545	541.5	3.5	.65	.4225 s.
21	493 516	504.5	11.5	2.28	5.1984 s.
	533 542	537.5	4.5	.84	.7056 s.
22	592 606	599	7	1.17	1.3689 s.
	632 633	632.5	.5	.08	.0064 s.
23	652 655	653.5	1.5	.23	.0529 s.
	601 630	615.5	14.5	2.35	5.5225 s.
24	526 551	538.5	12.5	2.32	5.3824 s.
	515 530	522.5	7.5	1.43	2.0449 s.
	530 541	535.5	5.5	1.03	1.0609 s.
26	644 614	629	15	2.38	5.6644 s.

Total number of degrees of freedom = 99. $\Sigma D^2 = 846.26$

$$\sigma = \sqrt{\frac{846.26}{99}} = \pm 2.92$$

TABLE 2.

Estimation of the errors involved in the determination of lactation yield of protein when three weekly samples are taken instead of weekly ones and when the true yields of milk are used in the calculation of protein yield.

Cow No.	Milligrams of T.P.N. in 100 grams of milk.	Means	d (Absolute values of the differences from the mean.)	D (d expressed as % of mean.)	D^2
1	459	453	6	1.33	1.7689
	436		17	3.76	14.1376
	464		11	2.43	5.9049
2	453	460	7	1.52	2.3104
	470		10	2.17	4.7089
	457		3	.65	.4225
3	465	443.66	21.34	4.80	23.04
	440		3.66	.82	.6724
	426		17.66	3.93	15.4449
	460	497.66	37.66	7.53	56.7
	523		25.34	5.07	25.7049
	510		12.34	2.47	6.1009
4	440	430	10	2.32	5.3824
	420		10	2.32	5.3824
	430		0	0	0
	430	426	4	.94	.8836
	408		18	4.23	17.8929
	440		14	3.29	10.8241
5	503	472.66	30.34	6.4	40.96
	451		21.66	4.57	20.8849
	464		8.66	1.83	3.3489
6	468	480.33	12.33	2.56	6.5536
	482		1.67	.35	.1225
	491		10.67	2.22	4.9284
7	552	552.33	.33	.06	.0036
	550		2.33	.42	.1764
	555		2.67	.48	.2304
8	546	548.33	2.33	.42	.1764
	527		21.33	3.88	15.0544
	572		23.67	4.31	18.5761
	530	507.33	22.67	4.47	19.9809
	481		26.33	5.19	26.9361
	511		3.67	.72	.5184

Table 2 (contd.)

Cow No.	Milligrams of T.P.N. in 100 grams of milk	Means	d (Absolute values of the differences from the mean.)	D (d expressed as % of mean.)	D^2
9	448	445.33	2.67	.60	.3600
	447		1.67	.37	.1369
	441		4.33	.97	.9609
	452	460.66	8.66	1.88	3.5344
	467		6.34	1.38	1.9044
	463		2.34	.51	.2601
	503	505.33	2.33	.46	.2116
	509		3.67	.73	.5329
	504		1.33	.26	.0676
10	453	474	21	4.43	19.6249
	509		35	7.38	54.4644
	460		14	2.95	8.7025
11	446	440.33	5.67	1.29	1.6641
	430		10.33	2.34	5.4756
	445		4.67	1.06	1.1236
	440	435.66	4.34	.99	.9801
	418		17.66	4.04	16.3216
	449		13.34	3.05	9.3025
	450	444.33	5.67	1.27	1.6129
	431		13.33	3	9.0000
	452		7.67	1.72	2.9584
12	526	513	13	2.53	6.4009
	499		14	2.73	7.4529
	514		1	.19	.0361
13	477	489.66	12.66	2.58	6.6564
	500		10.34	2.11	4.4521
	492		2.34	.48	.2304
14	607	601.33	5.67	.94	.8836
	589		12.33	2.04	4.1616
	608		6.67	1.11	1.2321
15	492	479.33	12.67	2.65	7.0225
	480		.67	.14	.0196
	466		13.33	2.79	7.7841
16	557	559.33	2.33	.42	.1764
	561		1.67	.30	.09
	560		.67	.12	.0144
17	523	533.33	10.33	1.93	3.7249
	540		6.67	1.25	1.5625
	537		3.67	.69	.4761

Table 2 (contd.)

Cow No.	Milligrams of T.P.N. in 100 grams of milk	Means	d (Absolute values of the differences from the mean.)	D (d expressed as % of mean.)	D^2
18	506	534.33	28.33	5.30	28.09
	562		27.67	5.17	26.7289
	535		.67	.12	.0144
19	542	544.33	2.33	.43	.1849
	548		3.67	.68	.4624
	543		1.33	.24	.0576
20	513	528	15	2.83	8.0089
	517		11	2.08	4.3264
	554		26	4.91	24.1081
21	511	488.66	22.34	4.58	20.9764
	495		6.34	1.30	1.69
	460		28.66	5.88	34.5744
22	644	614.66	29.34	4.75	22.5625
	606		8.66	1.40	1.96
	594		20.66	3.35	11.2225
	606	623.66	17.66	2.83	8.0089
	632		8.34	1.33	1.7689
	633		9.34	1.49	2.2201
23	647	646	1	.15	.0240
	637		9	1.39	1.9321
	654		8	1.24	1.5376
24	526	542.66	16.66	3.06	9.3636
	562		19.34	3.56	12.6736
	540		2.66	.49	.2401
	562	528.33	33.67	6.36	40.4496
	540		11.67	2.20	4.84
	483		45.33	8.57	73.4449
25	515	528.66	13.66	2.58	6.6564
	530		1.34	.25	.0625
	541		12.34	2.33	5.4289

Total number of degrees of freedom = 101.

$$\Sigma D^2 = 900.9274$$

$$\sigma = \sqrt{\frac{900.9274}{101}} = \pm\ 2.99$$

Discussion and Conclusion.

The present writer (1) has shown that the total protein nitrogen decreases very rapidly during the first six weeks of lactation, and thereafter increases slightly till towards the end of the lactation, when the increase becomes more pronounced. If, in the randomized groups of two or three consecutive weeks, those corresponding to the two periods of rapid change are eliminated, relatively smaller limits of errors are obtained. Thus it is suggested that weekly samples, taken during the first six and the last four weeks of lactation, with fortnightly samples for the remainder, should give results which would not deviate seriously from those for weekly samples throughout the lactation. For practical purposes, however, a sufficient degree of accuracy would be obtained by fortnightly samples during the periods of rapid change, and samples taken at intervals of three weeks during the remainder of the lactation.

It is emphasized that these results are valid only when the daily yields of milk are known for the whole lactation and used for the calculation of protein yield; if this is not the case, *i.e.*, if the milk is recorded only at intervals, the limits of errors will obviously be greater.

Acknowledgement/

Acknowledgement.

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IS THE PROTEIN YIELD OF COW'S MILK A HEREDITARY CHARACTER ?

BY

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Contents.

Introduction

Many enquiries have been made into the mode of inheritance of total yield, fat content, and the fat yield of the milk of dairy cows. Owing to the complexity of the problem, many different methods have been employed by various investigators and at the present day there exists a huge and confusing literature upon the subject. Smith and Robison have done a critical survey of all the literature existing up to 1933(1). Smith has completed this work in 1935 (2), (3), and more recently in 1937 (4). Leroy has done a similar work in 1936 (5). From a carefull examination of these sources, it appears that the present state of knowledge about the precise mode of the inheritance of milk and fat producing capacity is limited and may be summarised as follows:

A) Milk production.

(1) The capacity for milk production is transmited from the parents to the offspring.

(2) The capacity for milk production is a complex/

plex character and cannot be considered as a simple Mendelian one.

This is all we know as scientifically sound sound about the subject. We know little of the mechanism of this transmission. Many genes of different nature (dominant, homomeric, heterosis, modifying, etc.) and of different number (3 pairs, 4 pairs, etc....) have been thought to be involved in the process by various investigators, but none of the proposed hypotheses can explain the fact in its entirety. The truth is that the problem is an extremely complex one, the yield of milk being greatly influenced by environmental conditions, as Leroy has pointed out "If is it possible to increase by adequate nutrition the yield of a single cow from 5,000 to 15,000 litres of milk, what is the figure which may be taken as an index of the genetic value of the animal ?" (5)

B) <u>Butter-Fat</u>.

Our knowledge about the heredity of butter-fat production is even poorer than for the heredity of the milk itself. The greater part of the investigations have been concerned not with the yield of butter produced by cows, but with the percentage of fat in their milk. It seems that the percentage of fat in milk is also a hereditary character and is transmitted/

transmitted independently from milk producing capacity. It appears also that within certain limits fat production is inherited independently of total yield of milk. There is however a high positive correlation between the two. Here again we are ignorant of the mechanism of its transmission and the various investigators do not agree on the number of factors involved.

Smith (6), in dealing with quantitative characters in plants, states that "They present particular difficulty because heritable variations are masked by larger non-heritable variations which make it difficult to determine the genotypic values of individual plants..." He also stresses that in plant breeding the use of arbitrary ratios "are likely to be inefficient as indices to the genetic value of either of the characters whose ratio is observed." The same is true for quantitative characters in animals, and the use of percentages of fat in milk may not be as efficient as a separate study of fat yield and milk yield would be. The efforts of the investigators in this direction may prove to be more fruitful in future than it has been up to now.

Hitherto no work has been accomplished concerning/

concerning the heredity of the proteins of milk, probably because the work in this direction is more laborious than for the fat and less important economically. Nevertheless the proteins of milk beside their body-building properties are used as raw material in a great number of industries. Accordingly it was thought worth while to study whether the protein-production in cow's milk was influenced by genetical factors. Hence a series of investigations for this purpose was planned in 1936 and 1937. Owing to the extreme complexity of the problem and the fact that the protein content of milk is influenced by a great number of factors as breed, age, stage of lactation, individuality of the cow, etc....., it is not possible to analyse thoroughly the problem unless the investigation is carried on for several lactations. But with the data already available, it has been possible to draw some general conclusions, not as results of a genetic experiment, but only by inference.

Material of work.

Twenty seven cows were chosen at the farm of the Institute. These cows were of different ages, and at different stages of lactation. They were of the following breeds:

3 Beef Shorthorn/

3 Beef Shorthorn

1 Dairy Shorthorn

2 Beef Dairy Shorthorn

2 Dairy Beef Shorthorn

2 Shorthorn Ayrshire

14 Ayrshire

3 Jersey

Method of work.

All the usual precautions were taken in the collection of samples which were representative of twenty four hours yield of individual cows and were taken at intervals of seven days from each cow.

The percentage of total protein nitrogen was determined by precipitation by trichloracetic acid and a K~~e~~djeldahl digestion as described by Sanders (7).

The systematic errors of the experiment were determined by ten analyses carried out on the same sample of milk. The mean and the standard error of these ten determinations were:

$$\bar{m} = 0.5921$$

$$= 0.0043$$

Analysis and interpretation of the data.

About 380 samples of milk were analysed, and examined to find whether there were any relation between/

between the yield of milk and the yield of protein. A positive correlation of 0.951 was found between the two variates. A priori a positive and high correlation was to be expected between the two variates, since the protein is part of milk and there is no milk without protein. But such a high figure was not anticipated owing to the fact that with the same data there was previously obtained a negative correlation of 0.454 between the yield of milk and the percentage of total protein nitrogen.

Figures 1 and 2 show the corresponding correlation tables with all details concerning the two variates.

A careful examination of the Figure 1 suggests two ideas:

(1) The yield of milk being so closely correlated to the protein yield, one can legitimately think that they are both affected by the same cause or causes. It is known that the yield of milk is influenced by heredity, and this indicates that the yield of protein is also influenced by heredity. But this is only a hypothesis suggested by observation, and should not be considered as a proof.

(2) Further, Figure 1 shows that in the region corresponding to the high yields of milk (which is called/

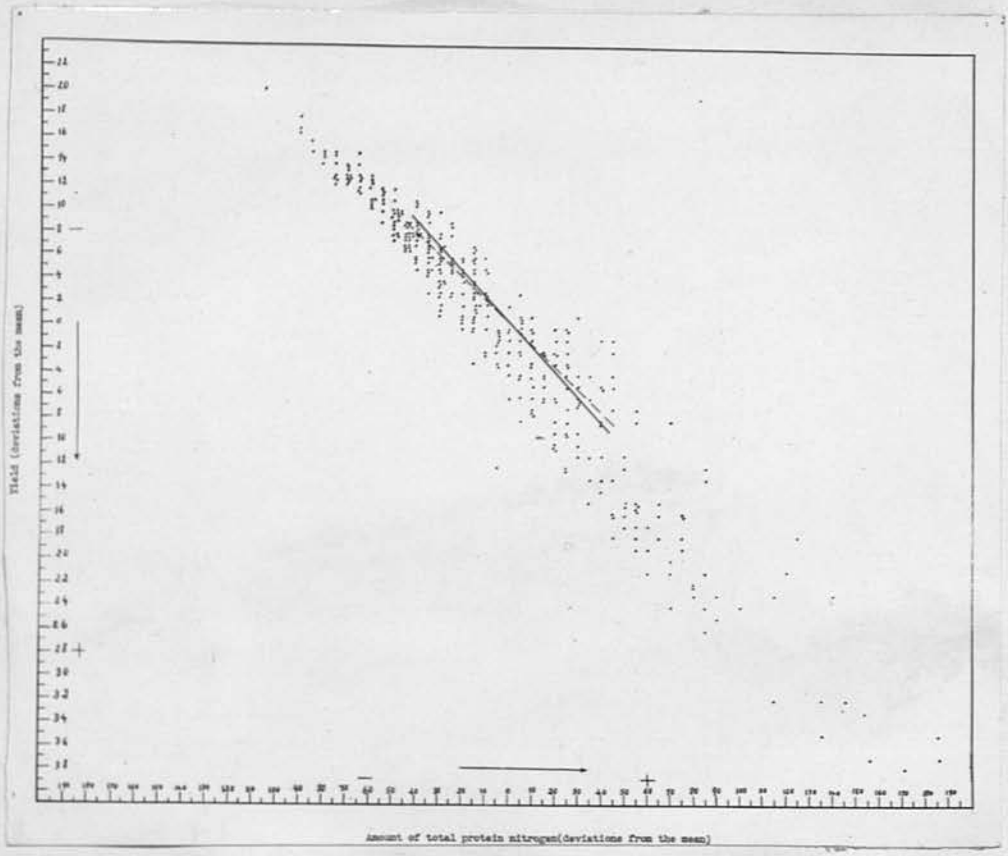
Yield (deviations from the mean)
Amount of total protein nitrogen(deviations from the mean)

Fig. 1.

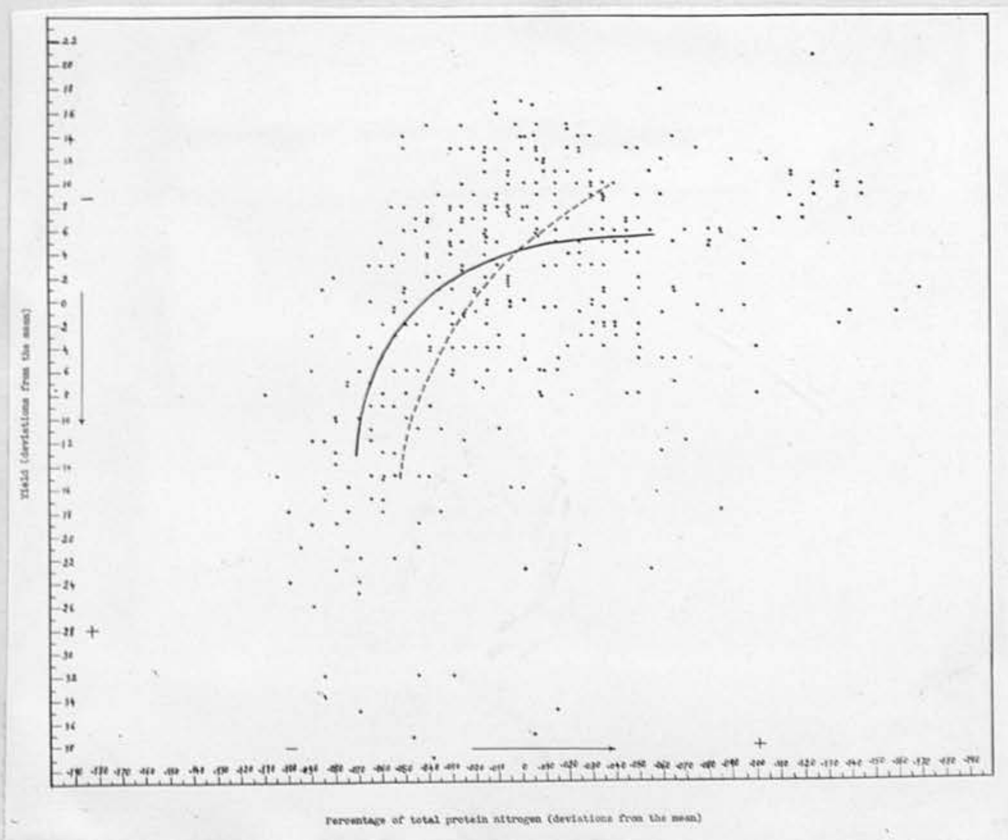
Yield (deviations from the mean)
Percentage of total protein nitrogen (deviations from the mean)

Fig. 2.

called region 1), the dots are much more scattered than in region 2 corresponding to the low yields. It means that if there were samples of milk corresponding to the first region only, the correlation coefficient would have been smaller than 0.951. Whereas with samples corresponding to the second region only, the correlation coefficient would have been greater than 0.951.

Considering that the samples in the region 1 belong generally to high milkers, that is to say to genetically improved breeds, and those in the region 2 to poorer breeds, one feels inclined to think that through the improvement of breeds there has been a regressive change in correlation. In other words, the production of proteins seems to be less closely dependent on the production of the milk itself with advanced breeds than with poorer breeds. Considering that through ages man has been selecting cows only in respect of their yield of milk, without any consideration as to the protein content of this milk, it is reasonable to think that this change in correlation is due to the effect of selection; and this would mean that besides the causes mentioned above, there are others of less importance which may influence yield of milk without affecting protein yield/

yield. Furthermore attention should be drawn to the parallel relationship of fat and protein to total yield of milk. Both fat yield and protein yield show a high correlation with the yield of milk. The majority of investigations on fat percentage show a nul or negative correlation to the yield of milk. The present study and the previous figures of Tocher (8) both show a significantly negative correlation between protein nitrogen and the yield of milk. Now, both fat yield and percentage have been shown to be heritable characters. It is therefore not unlikely that the same may apply to the protein of milk.

With the present data it is not possible to go further, but the work is being continued and we may hope it will throw some more light upon this complex problem.

Summary

1) The present state of knowledge about the inheritance of milk yield and fat is summarised.

2) The design of the present investigation with material and method of work are briefly described.

3) From the analysis of 380 samples of milk and examination of the correlation table between the yield of milk and the yield of protein it is suggested: (1) that the yield of protein is inherited with the yield of milk. (2) that there are causes which may affect the yield of milk, without affecting the yield/

yield of protein.

It is emphasized that the above hypothesis are suggested by observation and should not be considered as proof.

Acknowledgements

The writer wishes to acknowledge his gratitude to Professor F. A. E. Crew for the facilities received at the Institute of Animal Genetics. He is also indebted to Mr A. D. Buchanan Smith and to Dr A. M. Smith for their valuable help and advice throughout the work.

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THE ANALYTICAL DATA.

Results of analyses of 380 samples of milk taken from 27 individual cows at different stages of lactation. Each sample is representative of the whole milk given by each cow in 24 hours The interval between two successive analyses of the milk of the same cow is seven days. The methods adopted for the analyses were:

Sanders's method for the total protein nitrogen,

Moir's method for the casein nitrogen,

Albumin + Globulin nitrogen was determined by the difference.

The Gerber method was used for the determination of butter-fat. This was done at the farm by Mr T. Stoddart, B.Sc., the manager of the farm. He carried out his analyses not on samples representing the 24 hours yield, but on samples taken from each milking of each cow during the experiment. The writer converted his results by the following method of computation into results for daily samples.

If A, B, C are set respectively for the number of pounds of milk given by a cow in her first, second, and third milking in a day, and a, b, c respectively for the percentage of butter fat as determined by Mr T. Stoddart, then the amount of butter fat produced during the time in question, expressed in pounds will be: $F = \frac{Aa + Bb + Cc}{100}$

and/

and the percentage of fat in a single sample representing the 24 hours yield will be: $\frac{100\ F}{A + B + C}$.
The butter fat was determined in the same milk as protein for the following purpose:

Knowing the perdentage of fat and the specific gravity of each sample, the use of Tocher's prediction formulae (1) would make it possible to determine the percentage of solids-not-fat in each sample, and knowing this, it would be possible to have the percentage of lactose + ash by subtracting the percentage of protein from that of solids-not-fat. The use of Veith's Ratio and Sherman's formulae (2) would then make it possible to determine the percentage of ash and the percentage of lactose, and thus to study all the principal components of milk from different angles as variations, heredity, etc..... The writer did not have time to carry out this work.

It was also thought that it might be possible to determine whether pregnancy had any influence on the composition of milk; the amount of the data so far collected, however, was not judged to be sufficient to permit of a statistical analysis in this respect.

Each one of the following pages contains the information available for one cow. The particulars concerning each cow are taken from the herd books of the Institute. Observations on each cow are given by Mr Stoddart, the farm manager.

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Proud Lustre

Breed: Beef/Dairy Shorthorn

Date of birth: 30/6/32

Date of last calving: 29/3/37

Sire: Royal Airman

Observations:

Was not pregnant during the experiment

Was out to the grass from the 27/4

Was dried off on the 7/8

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
1/4/37	33	.612	.202	.452	.149	.160	.053	2.5	.82
8/4	40	.486	.194	.392	.157	.094	.038	3.5	1.40
15/4	39.5	.427	.169	.346	.137	.081	.032	3.5	1.37
22/4	36			.319	.115			3.6	1.30
29/4	31.5	.421	.133	.324	.102	.097	.030	2.8	.88
6/5	35.5	.427	.152	.338	.120	.089	.031	3.4	1.22
13/5	27	.459	.124	.367	.099	.092	.025	3.3	.89
20/5	32.5	.436	.142	.345	.112	.091	.029	2.6	.84
27/5	30.5	.464	.142	.374	.114	.089	.027	2.7	.84
3/6	23.5	.471	.111	.362	.085	.108	.025	2.5	.60
10/6	31.5	.463	.146	.351	.110	.111	.035	2.6	.82

Rothes Belle

Breed: Beef/Shorthorn

Date of birth: 5/2/32

Date of last calving: 21/3/37

Sire: Collynie Royal Autocrat

Observations:

Was not pregnant during the experiment

Was out to the grass from the 27/4

Was dried off on the 7/8

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
25/3/37	43.5	.592	.258	.469	.204	.123	.053	3.7	1.63
1/4	48	.512	.246	.409	.196	.102	.049	3.2	1.53
8/4	49.5	.437	.216	.354	.175	.083	.041	3.1	1.54
15/4	46.5	.433	.201	.341	.158	.092	.042	2.7	1.28
22/4	43	.409	.176	.309	.133	.100	.043	2.7	1.18
29/4	40	.405	.162	.318	.123	.087	.035	3.4	1.36
6/5	37	.422	.156	.336	.124	.086	.032	3.1	1.15
13/5	40	.442	.177	.352	.141	.090	.036	3	1.21
20/5	37.5	.482	.181	.388	.145	.094	.035	2.3	.88
27/5	38.5	.453	.174	.359	.138	.093	.036	3.3	1.25
3/6	34.5	.470	.162	.365	.126	.105	.036	2.7	.94
10/6	31.5	.457	.144	.341	.107	.117	.037	3.9	1.22

Balgreddan Countess

Breed: Ayrshire

Date of birth: 22/3/30

Date of last calving: 27/3/37

Sire: Lord Milton Campaigner

Observations:

Was not pregnant during the experiment

Was out to grass from the 17th/4

Date	Milk Yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Br.-Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
31/3/37	26.5	.672	.178	.569	.151	.102	.027		
7/4	48	.563	.270	.474	.227	.090	.043	4.1	2
14/4	57.25	.480	.275	.394	.225	.086	.049	4	2.3
21/4	57.5	.465	.267	.384	.221	.081	.046	4	2.3
28/4	60	.440	.264	.368	.221	.072	.043	4.3	2.6
5/5	57.5	.426	.245	.373	.214	.054	.031	4.1	2.4
19/5	64	.468	.300	.403	.258	.065	.042	3.4	2.2
26/5	62	.460	.285	.384	.238	.076	.047	2.9	1.80
2/6	60.5	.523	.316	.431	.261	.091	.055	3.1	1.88
9/6	62	.510	.316	.429	.266	.081	.050	3.2	1.96

Auchenbrain Bunty 66

Breed: Ayrshire

Date of birth: 3/11/30

Date of last calving: 9/3/37

Sire: Lyonston Douglas 25768

Observations:

Was not pregnant during the experiment

Was out to grass from the 17/4

Takes milk fever each year after calving

Was in heat in the 25/5

Date	Milk Yield (lbs)	T.P.N. %	T.P.N. y(lb)	C.N. %	C.N. y(lb)	A.N.+G.N %	A.N.+G.N y(lb)	Fat %	Fat y(lb)
18/3/37	37.25	.580	.216	.486	.181	.094	.035		
24/3	43.5	.476	.207	.388	.169	.087	.038		
30/3	47	.453	.213	.386	.181	.068	.032	4.3	2.33
6/4	50	.440	.220	.370	.185	.070	.035	3.5	1.75
13/4	51	.420	.214	.362	.185	.058	.029	3.5	1.78
20/4	48.5	.430	.209					3.3	1.60
27/4	49.5	.408	.202	.330	.167	.071	.035	3.7	1.84
4/5	47.5	.440	.209					3.8	1.83
11/5	49.75	.464	.231	.383	.190	.081	.040	3.9	1.94
18/5	48	.460	.221	.403	.193	.057	.027	3.5	1.70
25/5	36	.462	.166	.404	.145	.058	.021	2.1	.76
1/6	45	.451	.203	.380	.171	.071	.032	4.4	.20
8/6	46.5	.462	.215	.394	.183	.068	.032	4.1	1.93

Peggy

Breed: Shorthorn/Ayrshire

Date of birth: 1/1/33

Date of last calving: 15/3/37

Sire: Waterloo Hero

Observations:

Was out to the grass from the 27/4

Was not pregnant during the experiment

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
2/4/37	40.5	.455	.184	.391	.158	.063	.025	3.7	1.5
9/4	41.5	.425	.176	.357	.148	.068	.028	3.6	1.49
16/4	42	.442	.186	.372	.156	.070	.029	2.9	1.24
23/4	37.5	.420	.157	.359	.135	.061	.023	3.4	1.26
30/4	33.5	.450	.151	.373	.125	.076	.025	2.9	.98
7/5	33.5	.404	.135	.334	.112	.070	.023	3.6	1.21
14/5	41.5	.433	.180	.369	.153	.064	.026	3.5	1.45
21/5	41	.503	.206	.400	.164	.103	.042	2.1	.88
28/5	42.5	.451	.192					4.2	1.77
4/6	44.5	.464	.206	.380	.164	.084	.037	3.6	1.51
11/6	41	.452	.185	.368	.151	.085	.035	3.6	1.50

Meg Ramsay

Breed: Beef Shorthorn

Date of birth: 26/5/34

Date of last calving: 28/1/37

Sire: Royal Airman

Observations:

Was out to the grass from the 27/4

Was not pregnant during the experiment

Date	Milk yield (lbs)	T.P.N. %	T.P.N. y(lb)	C.N. %	C.N. y(lb)	A.N.+G.N. %	A.N.+G.N. y(lb)	Fat %	Fat y(lb)
18/2/37	24.5	.475	.116	.400	.098	.075	.018	3.7	.90
25/2	25	.445	.111	.394	.098	.051	.013	3.8	.94
4/3	24	.488	.117	.388	.093	.100	.024	3.7	.90
11/3	22	.476	.105	.385	.085	.091	.020	4.3	.95
18/3	20	.471	.094	.398	.080	.073	.015	3.5	.86
25/3	19.5	.477	.093	.393	.077	.084	.016	3.4	.69
1/4	20	.482	.096	.399	.080	.082	.016	3.5	.68
8/4	20	.480	.096	.404	.081	.076	.015	3.8	.71
15/4	19.5	.461	.090	.397	.077	.064	.012	4.2	.74
22/4	17	.468	.080	.390	.066	.078	.013	4.2	.72
29/4	17	.482	.082	.403	.068	.080	.014	4.3	.71
6/5	18.5	.491	.091	.405	.075	.086	.016	4.0	.80
13/5	18.5	.509	.094	.427	.079	.082	.015	4.2	.75
20/5	15.5	.528	.082	.440	.068	.088	.014	2.9	.66
27/5	19	.514	.098	.418	.079	.096	.018	3.9	.56
3/6	19.5	.527	.103	.431	.084	.096	.019	5.9	.77
10/6	17	.505	.086						1.01

Dreaming Lass

Breed: Jersey

Date of birth: 27/10/33

Date of last calving: 19/1/37

Sire: Sybil's Crown Prince

Observations:

Was served on the 25/4/37, is pregnant

Was out to the grass from 1/5

Date	Milk yield (lbs)	T.P.N. %	T.P.N. y(lb)	C.N. %	C.N. y(lb)	A.N.+G.N. %	A.N.+G.N. y(lb)	Fat %	Fat y(lb)
17/2/37	12	.487	.058	.391	.047	.097	.012	2.8	.34
24/2	29.5	.493	.145	.409	.120	.084	.025	3.7	1.09
3/3	26	.484	.126	.410	.106	.074	.019	4	1.03
10/3	26.25	.478	.125	.386	.101	.092	.024	3.8	1.01
17/3	24	.457	.110	.354	.085	.102	.024	4.6	1.10
24/3	21.5	.460	.099	.381	.082	.079	.017	3.6	.78
31/3	21.5	.469	.101	.318	.068	.150	.032	3.9	.84
7/4	18.5	.462	.085	.388	.072	.074	.014	3.8	.71
14/4	18	.469	.084	.382	.069	.088	.016	3.7	.67
21/4	17.5	.455	.080	.347	.061	.108	.019	3.8	.67
28/4	15.5	.484	.075	.392	.061	.092	.014	4.2	.65
5/5	17	.505	.086	.386	.066	.119	.020	4.3	.74
12/5	17.25	.498	.086	.407	.070	.091	.016	4.5	.77
19/5	17.5	.552	.097	.458	.080	.094	.016	4.3	.75
26/5	15	.550	.082	.447	.067	.103	.015	4.3	.64
2/6	12.5	.555	.069	.456	.057	.099	.012		
9/6	13.25	.570	.075	.467	.062	.104	.014	4.4	.58

Caldaria

Breed: Jersey

Date of birth: 5/4/33

Date of last calving: 16/1/37

Sire: Seymour Royal Lad

Observations:

Was not pregnant during the experiment

Was out to grass from the 1/5

One of the quarters is useless, mastitis setting in.

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
17/2/37	27	.549	.148	.406	.110	.144	.039	4.7	1.27
24/2	25.5	.517	.132	.416	.106	.101	.026	4.1	1.06
3/3	24.5	.489	.120	.416	.102	.073	.018	3.6	.89
10/3	23	.531	.099	.425	.098	.105	.024	3.7	.86
17/3	21.5			.427	.092			4.0	.87
24/3	18.75	.546	.102	.445	.083	.101	.019	4.7	.88
31/3	20	.527	.105	.428	.086	.099	.020	4.2	.85
7/4	7	.572	.040	.435	.030	.092	.010	7.8	.55
14/4	10.5	.530	.056	.441	.046	.089	.009	4.3	.45
21/4	12	.481	.058	.396	.047	.084	.010	5.8	.70
28/4	11.5	.511	.059	.471	.054	.040	.005	4.3	.50
5/5	10	.484	.048	.430	.043	.055	.005	5.1	.51
12/5	12.75	.496	.063	.409	.052	.088	.011	4.9	.62
19/5	13	.519	.067	.420	.055	.099	.013	5.1	.66
26/5	13	.521	.068	.440	.057	.081	.010	3.5	.45
2/6	15	.543	.081	.437	.065	.106	.016	4.3	.65
9/6	14.5	.539	.078	.446	.064	.093	.014	4.9	.71

Gay Lustre

Breed: Beef/Dairy Shorthorn

Date of birth: 24/6/32

Date of last calving: 12/1/37

Sire: Royal Airman

Observations:

Was served on the 1/6/37

Was out to the grass from 27/4

Was dried off on the 17/7

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
18/2/37	42.5	.425	.181	.343	.146	.081	.034	3.4	1.47
25/2	44	.431	.190	.336	.148	.095	.042	2.7	1.20
4/3	43.5	.432	.188	.340	.148	.092	.040	3.0	1.33
11/3	40	.448	.179	.348	.139	.101	.040	3.5	1.40
18/3	38.5	.448	.172	.353	.136	.095	.036	3.2	1.23
25/3	34	.447	.152	.346	.118	.101	.034	3.3	1.12
1/4	31	.441	.137	.336	.104	.105	.032	3.5	1.10
8/4	31	.452	.140	.343	.106	.108	.033	3.4	1.06
15/4	29.5	.467	.138	.345	.102	.122	.036	3.2	.86
22/4	27.5	.463	.127	.359	.099	.104	.029	3.3	.91
29/4	22	.442	.097	.321	.071	.120	.026	3.6	.80
6/5	22.5	.452	.102	.341	.077	.110	.025	3.4	.76
13/5	22	.476	.105	.370	.081	.106	.023	3.5	.77
27/5	23	.503	.116	.375	.086	.128	.029	3.0	.69
3/6	17.5	.509	.089	.387	.068	.122	.021	2.8	.50
10/6	14.5	.504	.073	.354	.051	.150	.022	2.8	.41

Mrs Mollison

Breed: Shorthorn/Ayrshire

Date of birth: 4/7/32

Date of last calving: 7/2/37

Sire: Royal Airman

Observations:

Was out to the grass from the 27th/4

Was not pregnant during the experiment

Was dried off on the 7/8

Date	Milk Yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
2/4/37	27.5	.496	.136	.366	.100	.130	.036	3	.84
9/4	25.5	.452	.115	.364	.093	.087	.022	3.4	.87
16/4	24	.424	.102	.346	.083	.077	.018	3.3	.79
23/4	23.5	.436	.102	.336	.079	.101	.024	3.4	.79
30/4	20.5	.448	.092	.356	.073	.091	.019	3.7	.76
7/5	22.5	.449	.101	.361	.081	.088	.020	3.6	.82
14/5	25.5	.453	.156	.358	.091	.095	.024	3.6	.92
21/5	23.5	.509	.120	.414	.097	.094	.022	2.8	.67
28/5	17.5	.460	.080	.358	.063	.102	.019	4	.70
4/6	23.5	.492	.116	.411	.096	.082	.019	3.6	.84
11/6	20.5	.494	.101	.406	.083	.088	.018	3.2	.65

Auchenbrain Bloomer

Breed: Ayrshire

Date of birth: 6/11/31

Date of last calving: 3/12/36

Sire: Lyonston Douglas 25768

Observations:

Was served on the 2/4/37, is pregnant

Was out to grass from the 17/4

Date	Milk Yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Br.-Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
16/2/37	46.5	.535	.249	.429	.199	.106	.049	3.4	1.58
23/2	46.5	.415	.193	.344	.160	.071	.033	3.4	1.59
2/3	44.5	.417	.186	.353	.157	.063	.028	3.9	1.72
9/3	43.5	.450	.196	.351	.153	.099	.043	4.5	1.95
16/3	38.5	.431	.166	.356	.137	.075	.029	3.4	1.32
23/3	34.5	.452	.156	.377	.130	.075	.026	3.6	1.24
30/3	34.5	.446	.154	.356	.123	.090	.031	3.9	1.36
6/4	35.5	.430	.153	.367	.130	.063	.022	2.8	1.00
13/4	32	.445	.142	.355	.114	.090	.029	3.5	1.12
20/4	28.25	.440	.124	.350	.099	.090	.025	3.1	.89
27/4	28	.418	.117	.325	.091	.093	.026	3.1	.88
4/5	27	.449	.121	.353	.095	.096	.026	3.3	.89
11/5	29.25	.445	.130	.348	.102	.097	.028	3.3	.96
18/5	32	.489	.156	.464	.148	.025	.008	3.4	1.08
25/5	29	.467	.135					3	.87
1/6	28.5	.468	.133	.372	.106	.096	.027	3.6	1.02
8/6	31	.481	.149	.367	.114	.113	.035	4.4	1.36

ROSEBUD

Breed: Dairy Shorthorn

Date of birth: 31/10/31

Date of last calving: 8/11/36

Sire: Ruby Prince

Observations:

Was served on the 19/1

Was out to the grass from the 27/4

Was dried off on the 17/7

Date	Milk yield (lbs)	T.P.N. %	T.P.N. y(lb)	C.N. %	C.N. y(lb)	A.N.+G.N. %	A.N.+G.N. y(lb)	Fat %	Fat y(lb)
18/2/37	40	.470	.188	.393	.157	.076	.030	3	1.20
25/2	41	.484	.198	.404	.166	.081	.033	2.9	1.19
4/3	41	.508	.208	.418	.171	.090	.037	3	1.25
11/3	31	.526	.163	.426	.132	.100	.031	3	.94
18/3	36	.499	.180	.413	.149	.086	.031	3.2	1.15
25/3	31	.514	.159					3.5	1.09
1/4	29	.532	.154	.443	.128	.089	.026	3.5	1.03
8/4	30.5	.510	.155	.414	.126	.096	.029	3.4	1.04
15/4	30.5	.486	.148	.405	.123	.082	.025	3.3	1.01
22/4	28	.508	.142	.412	.115	.096	.027	3.5	.99
29/4	23	.502	.117	.403	.093	.099	.023	3.3	.76
6/5	18	.492	.089	.390	.070	.102	.018	3.8	.69
13/5	22	.537	.118	.442	.097	.095	.021	3.6	.79
20/5	27	.547	.148	.454	.122	.093	.025	2.6	.70
27/5	25.5	.525	.134	.430	.110	.095	.024	3.6	.93
3/6	22	.535	.118					3.9	.85
10/6	19	.542	.103					3.7	.70

Mary Ramsay

Breed: Dairy/Beef Shorthorn

Date of birth: 26/6/33

Date of last calving: 10/11/36

Sire: Waterloo Hero

Observations:

Was served on the 19/4/37

Was out to grass from 27/4

Was dried off on the 5/6

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
19/2/37	17	.493	.084	.412	.070	.081	.014	3.3	.56
26/2	17.5			.415	.073			3.5	.61
5/3	17.5	.477	.083	.359	.063	.118	.021	3.7	.65
12/3	16	.500	.080	.422	.067	.078	.012	3.7	.59
19/3	14	.492	.069	.406	.057	.086	.012	5.8	.81
26/3	15			.413	.062			3.9	.58
2/4	13.5	.513	.069	.426	.057	.086	.012	3.7	.50
9/4	16.5	.472	.078	.383	.063	.090	.015	3.7	.62
16/4	13	.493	.064	.409	.053	.084	.011	3.7	.48
23/4	12	.482	.058	.399	.048	.084	.010	4	.48
30/4	12	.457	.055	.385	.046	.072	.009	4.1	.49
7/5	11	.460	.051	.394	.043	.066	.007	3.4	.38
14/5	12	.513	.062	.416	.050	.097	.012	3.7	.44
21/5	13.5	.504	.068	.409	.055	.096	.013	2.4	.32
28/5	12.5	.500	.062	.409	.051	.091	.011	4.8	.60
4/6	12	.536	.063	.417	.050	.119	.014	3.1	.37

Cockburn Bunny

Breed: Ayrshire

Date of birth: 7/11/33

Date of last calving: 4/10/36

Sire: Carnell Selection

Observations:

Was served on the 11/1/37

and on the 26/2/37

Was out to grass from the 17/4

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
17/2/37	25	.556	.139	.488	.122	.068	.017	4.1	1.03
24/2	24	.679	.163	.473	.113	.207	.050	3.9	.94
3/3	25.75	.585	.151	.483	.124	.102	.026	3.7	.96
10/3	22.5	.607	.137	.481	.108	.126	.028	6.2	1.41
17/3	20.5	.589	.121	.488	.100	.101	.021	4.9	1.01
24/3	19.75	.608	.120	.505	.100	.103	.020	4.3	.85
31/3	19	.595	.113	.493	.094	.102	.019	4.5	.86
7/4	19.5	.590	.115	.477	.093	.113	.022	4.2	.83
14/4	19.75	.582	.115					4.6	.91
21/4	19.5	.516	.101	.478	.093	.038	.008	4.6	.89
28/4	16	.545	.087	.451	.072	.094	.015	5	.80
5/5	16.5	.545	.090	.461	.076	.085	.014	4.7	.78
12/5	18.25	.553	.101	.455	.083	.098	.018	4	.73
19/5	17.5	.585	.102	.485	.085	.100	.017	4.2	.73
26/5	20	.547	.109	.451	.090	.096	.019	4	.81
2/6	20.5	.574	.118	.471	.097	.103	.021	4	.82
9/6	19.5	.594	.116	.391	.076	.202	.039	4.2	.82

Consolation

Breed: Dairy/Beef Shorthorn

Datė of birth: 25/2/33

Date of last calving: 4/10/36

Sire: Waterloo Hero

Observations:

Was served on the 8/7/37

Was out to the grass on the 27/4/37

Had abortion during her first calving.

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
19/2/37	26	.503	.131	.393	.102	.110	.029	3.3	.86
26/2	28	.498	.139	.399	.112	.099	.028	3.2	.91
5/3	24	.465	.112	.402	.096	.062	.015	3.3	.80
12/3	21	.492	.103	.400	.084	.092	.019	3.6	.75
19/3	21.5	.480	.103	.378	.081	.102	.022	5.8	1.24
26/3	19.5	.466	.091	.385	.075	.081	.016	3.6	.71
2/4	20.5	.500	.102	.392	.080	.108	.022	3.4	.70
9/4	21.5	.468	.101	.372	.080	.095	.020	3.5	.76
16/4	19.5	.495	.097	.392	.076	.103	.020	3.5	.69
23/4	19	.496	.094	.392	.074	.104	.020	3.7	.70
30/4	16.5	.489	.081	.356	.059	.133	.022	4.2	.69
7/5	17.5	.479	.084	.363	.063	.115	.020	3.7	.65
14/5	20	.533	.107	.432	.086	.101	.020	3.8	.76
21/5	23	.504	.116	.394	.090	.110	.025	3.6	.84
28/5	18	.485	.087	.371	.067	.114	.020	3.5	.63
4/6	16.5	.524	.086	.403	.066	.121	.020	3.6	.59
11/6	17	.502	.085					2.8	.48

Cockburn Jess

Breed: Ayrshire

Date of birth: 30/1/34

Date of last calving: 25/9/36

Sire: Criffel Champion

Observations:

Was served on the 10/12/36, is pregnant

Was out to the grass from the 17/4

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
15/2/37	29	.483	.140	.399	.116	.084	.024	3.4	1.00
22/2	28.5	.540	.154	.395	.113	.145	.041	3.8	1.08
1/3	29.5	.547	.161	.344	.101	.203	.060	3.6	1.06
8/3	29.5	.498	.147	.407	.120	.090	.026	3.8	1.12
15/3	25	.504	.126	.413	.103	.091	.023	3.8	.95
22/3	25	.496	.124	.388	.097	.108	.027	3.7	.88
29/3	26.5	.489	.130	.404	.107	.085	.022	3.8	1.02
5/4	27	.480	.130	.402	.108	.078	.021	3.7	.99
12/4	25.75	.473	.122	.380	.098	.093	.024	5.5	1.41
19/4	22.75	.500	.114	.409	.093	.091	.021	3.9	.89
26/4	18.25	.529	.097	.440	.080	.089	.016	4.6	.84
3/5	18	.561	.101	.465	.084	.096	.017	4.2	.76
10/5	17	.557	.095	.459	.078	.098	.017	4.5	.76
17/5	21	.561	.118	.441	.093	.120	.025	3.6	.76
24/5	17.5	.560	.098	.454	.097	.106	.018	3.4	.59
31/5	17	.582	.099	.463	.079	.118	.020	4.3	.73
7/6	14	.520	.073					4.9	.69

Cockburn Bloomer

Breed: Ayrshire

Date of birth: 18/6/34

Date of last calving: 24/9/36

Sire: Carnell Selection

Observations:

Was not pregnant during the experiment

Was out to grass from 17/4

Had two teats out of use as a result of mastitis.

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
16/2/37	15.5	.516	.080	.419	.065	.097	.015	4.1	.63
23/2	14	.523	.073	.423	.059	.100	.014	4.3	.60
2/3	15.5	.540	.084	.470	.073	.070	.011	4.1	.64
9/3	11.75	.537	.063	.442	.052	.095	.011	4.7	.55
16/3	12.25	.514	.063	.416	.051	.098	.012	4.6	.56
23/3	15	.508	.079	.424	.066	.084	.013	3.7	.58
30/3	12.5	.524	.065	.439	.055	.085	.011	4.2	.52
6/4	14	.505	.071	.381	.053	.123	.017	4.5	.63
13/4	12	.509	.061	.418	.050	.092	.011	3.4	.41
20/4	10.5	.469	.049	.380	.040	.089	.009	4.4	.46
27/4	8	.500	.040	.394	.031	.106	.008	6.7	.54
4/5	10	.507	.051	.411	.041	.096	.010	6.6	.66
11/5	10	.516	.052	.398	.040	.117	.012	5.2	.52
18/5	11	.509	.056	.387	.043	.121	.013	3.8	.42
25/5	12	.531	.064					3.7	.44
1/6	10			.406	.041			3.3	.33
8/6	10.75	.528	.057	.418	.045	.110	.012	3.8	.41

Balgreddan Jess

Breed: Ayrshire

Date of birth: 10/4/31

Date of last calving: 16/9/36

Sire: Chapelhill Emperor

Observations:

Was served on the 22/12/36, is pregnant

Was out to grass from the 17th/4/37

Date	Milk Yield (lbs)	T.P.N.		C.N.		A.+ G.N.		Br.-Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
15/2/37	40	.462	.185	.396	.158	.067	.027	3.5	1.41
22/2	37.5	.443	.166	.362	.136	.081	.030	3.2	1.21
1/3	38.25	.571	.218	.382	.146	.189	.072	2.9	1.11
8/3	40	.448	.179	.376	.150	.072	.029	3.3	1.34
15/3	35	.460	.161	.403	.141	.056	.020	3.5	1.22
22/3	33.5	.459	.154	.394	.131	.065	.022	4	1.34
29/3	36	.475	.171	.369	.133	.105	.038	3.4	1.21
5/4	36	.443	.159	.366	.132	.077	.028	3.4	1.24
13/4	35	.438	.153	.360	.126	.078	.027	3.6	1.28
19/4	32.5	.435	.141	.366	.119	.069	.022	2.7	0.88
26/4	28.5	.454	.129	.365	.104	.089	.025	3.9	1.12
3/5	29.5	.478	.141	.390	.115	.088	.026	4.4	1.31
10/5	31.5	.506	.159	.416	.131	.090	.028	3.2	1.01
17/5	33.5	.562	.188					3.8	1.26
24/5	26.5	.535	.142	.415	.110	.120	.032	3.6	.96
31/5	28	.559	.157	.440	.123	.119	.033	4.4	1.24
7/6	24.5	.573	.140	.460	.113	.112	.027	4	.98

Cockburn Countess

Breed: Ayrshire

Date of birth: 22/10/33

Date of last calving: 17/9/36

Sire: Hallcroft Rob Roy

Observations:

Was served on the 17/12/36

Was out to the grass from the 17/4/37

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
17/2/37	26	.651	.169	.573	.149	.077	.020	3.2	.84
24/2	25.5	.545	.139	.418	.107	.127	.032	3.3	.85
3/3	23.75	.558	.133	.434	.103	.124	.029	3.7	.87
10/3	24.5	.545	.134	.424	.104	.121	.030	2.3	.57
17/3	20.25	.555	.112	.424	.086	.131	.026	3.9	.79
24/3	21	.555	.117	.426	.089	.129	.027	3.7	.78
31/3	22	.542	.119	.425	.093	.117	.026	3.9	.87
7/4	20	.548	.110	.430	.086	.118	.024	3.4	.68
14/4	19.5	.543	.106	.415	.081	.128	.025	3.9	.77
21/4	19.5	.513	.100	.406	.079	.107	.021	3.8	.74
28/4	16.5	.547	.090	.436	.072	.111	.018	4.1	.68
5/5	14.5	.566	.082	.445	.064	.121	.017	4.1	.59
12/5	17	.495	.084	.389	.066	.106	.018	3.5	.60
19/5	18.5	.556	.103	.439	.081	.117	.022	3.4	.64
26/5	19	.554	.105	.430	.082	.123	.024	3.3	.63
2/6	19			.421	.080			3.6	.68
9/6	19.5	.563	.110	.432	.084	.131	.025	3.7	.72

Cockburn Gladys

Breed: Ayrshire

Date of birth: 19/12/33

Date of last calving: 14/9/36

Sire: Hallcroft Rob Roy

Observations:

Was served on the 12/1/37, is pregnant

Was out to the grass from the 17/4

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
16/2/37	31.25	.525	.164	.440	.137	.085	.026	3.5	1.09
23/2	33.5	.513	.171	.416	.139	.097	.032	3.6	1.21
2/3	33	.517	.171	.432	.142	.085	.028	3.5	1.15
9/3	32	.554	.177	.441	.141	.113	.036	2.5	.80
16/3	15 (A.M.)	.538	.081	.431	.065	.107	.016	3.7	.55
23/3	28.25	.534	.151	.438	.124	.096	.027	3.7	1.04
30/3	30.5	.527	.161	.436	.133	.091	.028	3.7	1.13
6/4	31	.522	.162	.423	.131	.100	.031	4	1.24
13/4	29.75	.560	.167	.444	.132	.116	.034	3.7	1.11
20/4	29			.432	.125			3.9	1.12
27/4	25	.538	.134	.433	.108	.105	.026	4.1	1.02
4/5	27.5	.545	.150	.448	.123	.096	.027	3.9	1.07
11/5	27.5	.560	.154	.451	.124	.110	.030	3.6	1.00
18/5	32.5	.573	.186	.394	.128	.179	.058	3.4	1.12
25/5	30.5	.562	.171	.452	.138	.110	.033	3.5	1.07
1/6	24.5	.545	.134	.440	.108	.105	.026	3.7	.92
8/6	30.5	.569	.174	.459	.140	.109	.033	3.6	1.10

Cockburn Magpie

Breed: Ayrshire

Date of birth: 3/2/34

Date of last calving: 3/9/36

Sire: Criffel Champion

Observations:

Was served on the 25/1/37, was pregnant during the experiment

Was out to the grass from the 17/4

Date	Milk yield (lbs)	T.P.N. %	T.P.N. y(lb)	C.N. %	C.N. y(lb)	A.N.+G.N. %	A.N.+G.N. y(lb)	Fat %	Fat y(lb)
15/2/37	29	.487	.141	.418	.121	.068	.020	4.2	1.21
1/3	27.50	.552	.152	.461	.127	.091	.025	4.3	1.18
8/3	26.25	.484	.127	.430	.113	.054	.014	4.2	1.11
15/3	26.00	.518	.135	.446	.116	.072	.019	4.4	1.14
22/3	25.5	.511	.130	.436	.111	.075	.019	4.4	1.12
29/3	25.75	.495	.127	.434	.111	.061	.016	4.4	1.13
5/4	25.25	.460	.116	.427	.107	.033	.008	4.2	1.07
12/4	24	.477	.114	.406	.097	.071	.017	4.2	1.02
19/4	19.5	.493	.096	.416	.081	.077	.015	3.8	.75
26/4	18.75	.516	.097	.443	.083	.073	.014	4.6	.86
3/5	17	.506	.086	.443	.075	.063	.011	4.8	.82
10/5	21	.528	.111	.448	.094	.080	.017	4.7	.98
17/5	21.5	.533	.115	.448	.096	.085	.018	3.6	.78
24/5	25	.542	.135	.461	.115	.080	.020	4.0	.99
31/5	24	.560	.134	.484	.116	.076	.018	4.5	1.08
7/6	22.5	.544	.122	.461	.104	.084	.019	3.8	.85

Balgreddan Magpie

Breed: Ayrshire

Date of birth: 16/3/31

Date of last calving: 28/8/36

Sire: Chapelhill Emperor

Observations:

Was served on the 18th/5/37

and 12th/6/37

Was out to grass from 17/4/37

This cow has always had a tendency to a delay in showing oestrus period, and is already one lactation behind cows of the same age. Injection of prolan and wheat germ oil had no effect. Good health.

Date	Milk Yield	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
15/2/37	30	.573	.172	.501	.150	.072	.022	3.8	1.15
22/2	31	.480	.149	.474	.147	.005	.020	3.5	1.06
1/3	28.5	.551	.124	.479	.136	.072	.020	4.4	1.27
8/3	29	.608	.176	.528	.153	.080	.023	4.4	1.28
17/3	26.5	.572	.152	.444	.118	.128	.034	6.5	1.80
22/3	27.5	.644	.177	.524	.144	.120	.033	4.4	1.20
29/3	25.75	.606	.156	.511	.132	.095	.024	4.2	1.08
5/4	26.5	.594	.157	.510	.135	.084	.022	4.4	1.17
12/4	20	.592	.118	.510	.102	.082	.016	3.8	.77
19/4	20.25	.606	.123	.493	.100	.113	.023	4	.81
26/4	18.25	.632	.115	.525	.096	.107	.019	4.8	.88
3/5	15.5	.633	.098	.564	.087	.069	.026	5.2	.80
10/5	18.5	.621	.115	.521	.096	.100	.018	4.6	.86
24/5	27	.541	.146	.462	.124	.079	.021	2.9	.78
31/5	22	.521	.115	.436	.096	.085	.019	2.9	.63
7/6	22.75	.525	.119	.421	.096	.104	.024	4.2	.95

Wonderful Standard's Carrie

Breed: Jersey

Date of birth: 20/3/32

Date of last calving: 20/8/36

Sire: Wonderful Standard

Observations:

Was served on the 29/10/36

Was out to grass from the 1/5/37

Date	Milk yield (lbs)	T.P.N. %	T.P.N. y(lb)	C.N. %	C.N. y(lb)	A.N.+G.N. %	A.N.+G.N. y(lb)	Fat %	Fat y(lb)
22/3/37	14.75	.627	.092	.524	.077	.103	.015	6.2	.91
29/3	17	.628	.107	.516	.088	.112	.019	5.9	1.00
5/4	16	.626	.100	.524	.084	.102	.016	5.6	.89
12/4	16	.540	.086	.481	.077	.060	.010	5.9	.94
19/4	15	.644	.097	.507	.076	.136	.020	6.5	.97
26/4	13	.601	.078	.501	.065	.100	.013	5.9	.77
3/5	14.25	.630	.090	.530	.075	.100	.014	4.8	.70
10/5	15	.647	.097	.538	.081	.109	.016	6.3	.95
17/5	16.5	.637	.105	.519	.085	.117	.019	4.8	.80
24/5	15.5	.654	.101	.530	.082	.124	.019	5.2	.81
31/5	18	.652	.117	.537	.097	.115	.021	4.9	.89
7/6	16	.655	.105	.548	.088	.107	.017	5.6	.90

Ada

Breed: Ayrshire

Date of birth: 20/2/29

Date of last calving: 16/6/36

Sire: Auchendrane Prince Vernon

Observations:

Was served on the 24th/1/37

Was out to the grass from the 27th/4

Was dried off on the 19th/6/37

Is poor in health and is not a good milker

Date	Milk Yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Br.-Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
19/3/37	15	.526	.079	.404	.061	.122	.018	4.7	.71
26/3	16.5	.562	.093	.448	.074	.114	.019	4.2	.69
2/4	17	.540	.092	.427	.073	.114	.019	4	.68
9/4	18	.483	.087	.405	.073	.079	.014	4	.73
16/4	17.5	.507	.089	.418	.073	.088	.015	4	.71
23/4	17.5	.496	.087	.388	.068	.108	.019	3.9	.68
30/4	15.5	.506	.078	.398	.062	.108	.017	4	.62
7/5	16.5	.500	.082	.389	.064	.111	.018	4.1	.67
14/5	17	.526	.089	.414	.070	.112	.019	3.9	.67
21/5	19	.551	.105	.423	.080	.128	.024	3.4	.65
4/6	12	.537	.064	.387	.046	.149	.018	3.5	.42
11/6	9	.499	.045	.357	.032	.141	.013	4	.36

Linnhead Favourite

Breed: Ayrshire

Date of birth: 28/4/31

Date of last calving 19/6/36

Sire: Harley Holm Gay Boy

Observations:

Was served on the 19/11/37, is pregnant

Was out to the grass from the 17/4

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(1b)	%	y(1b)	%	y(1b)	%	y(1b)
23/3/37	24.25	.457	.111	.334	.081	.122	.029	3.2	.79
30/3	22.5	.486	.109	.381	.086	.105	.024	3.2	.72
6/4	20.5	.480	.098	.362	.074	.118	.024	2.4	.50
13/4	18.5	.467	.086	.340	.063	.127	.023	3.3	.61
20/4	16.5	.515	.085	.378	.062	.137	.023	4.0	.66
27/4	14	.530	.074	.394	.055	.136	.019	4.4	.62
4/5	11	.541	.059	.405	.044	.135	.015	3.9	.43
11/5	12	.584	.070	.402	.048	.182	.022	4.0	.48
18/5	16.5	.571	.094	.391	.064	.181	.030	3.2	.53
25/5	11.5	.573	.066	.407	.047	.166	.019	4.2	.48
1/6	12.5	.561	.070	.403	.050	.158	.020	4.5	.56

Balgreddan Gladys

Breed: Ayrshire

Date of birth: 12/3/31

Date of last calving: 15/4/36

Sire: Chapelhill Emperor

Date	Milk Yield	T.P.N.		C.N.		A.+ G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
16/2/37	14	.644	.090	.517	.072	.126	.018	3.9	.55
23/2/37	13.5	.614	.083	.519	.070	.096	.013	3.6	.49
2/3/	10	.661	.066	.542	.054	.119	.012	4	.40

Keepsake

Breed:	Beef Shorthorn
Date of birth:	26/2/30
Date of last calving:	17/6/36
Sire:	Calrossie Achilles

Date	Milk yield (lbs)	T.P.N.		C.N.		A.N.+G.N.		Fat	
		%	y(lb)	%	y(lb)	%	y(lb)	%	y(lb)
19/3/37	8	.511	.041	.356	.028	.155	.012	3.9	.31
26/3	4	.634	.025	.458	.018	.176	.007	4.7	.19